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metals and alloys

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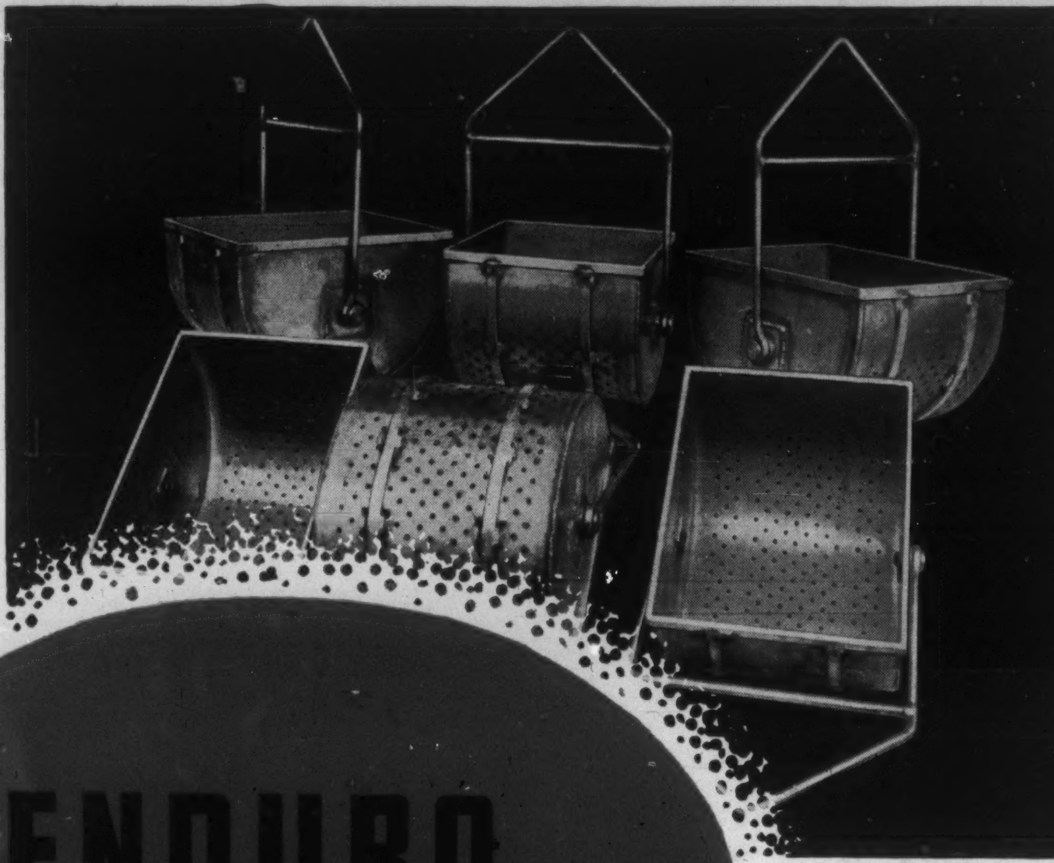

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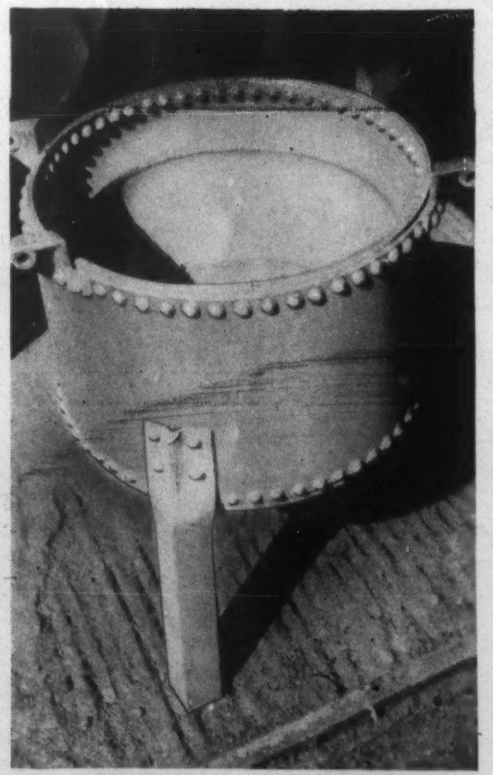

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Metals & Alloys, published monthly by Reinhold Publishing Corporation. Publication office: East Stroudsburg, Pa. Executive offices: 330 West 42nd St., New York, N. Y. Entered as second class matter June 12, 1934, at the Post Office at East Stroudsburg, Pa., under the Act of March 3, 1879. $3.00 a year in U. S.; foreign, $4.00. Vol. 6, No. 1.

E. Engin
Faxon

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METALS & ALLOYS

The Magazine of Metallurgical Engineering

Production • Fabrication • Treatment • Application

PUBLICATION OFFICE:
East Stroudsburg, Pa.
Editorial and Advertising Offices:
330 West 42nd St., New York, N. Y.
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Annual Subscription: U. S. Possessions, $3.00. All Other Countries, $4.00 (Remit by New York Draft). Single copy 40 cents.

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HIGHLIGHTS

by H. W. GILLETT

DO YOU want to know what metallurgical engineers are saying, the world over? Look in the Current Metallurgical Abstracts. Here are some of the points covered by authors whose articles are abstracted in this issue.

It's King's English

No, it's not an Americanism, it's King's English—Machinery uses the undignified but expressive phrase "cast-off" bars instead of "separately cast test specimens" (page MA 22 R 2).

Alloy Combinations for Rails

The alloy combinations mentioned by Kuehnel (page MA 34 R 6) as under trial in Austria and Germany for railroad rails, sound very similar to the modern low-alloy, high yield strength steels being developed for such uses as railway car bodies.

More Data on Wear

In a discussion of wear, Köster and Tonn (page MA 38 L1) conclude that hardness obtained by cold-working prior to installation in a service involving wear, is not effective in preventing wear.

Manganese in 18 and 8

Günzberg and coworkers (page MA 38 L 3) examine the replacement of Ni by Mn in 18:8 and conclude that while the two groups of alloys don't act exactly alike, the Fe Mn Cr alloys, plus Cu are useful and are better alloys for use against sulphur bearing gases at high temperature. It is odd that more attention is not paid in this country to sorting out the uses for 18:8 in which other cheaper austenitic alloys would serve.

More Light on Deep Drawing

More German work on deep-drawing problems is reported (page MA 24 R 1) by Hermann & Sachs, by Sommer (page MA 8 L 1) and in articles by Kayseler alone (page MA 8 L 3-5) and with coworkers. Extensive English work on wire drawing is reported by Thompson and collaborators (page MA 7 R 2-7).

Hot-Hardness Testing Discussed

Hot-hardness testing is discussed by Walzel (page MA 21 L 10) and by Hamasumi (page MA 36 R 8). Both investigators machine the test specimen into a sphere and use a dynamic method, and there is a similarity in their results.

Coating for Cast Iron Pots

According to Schied (page MA 4 L 5), magnesium powder and tar make a good coating for cast iron pots for melting aluminum.

Eggs, Cheese and Dynamite

Metal spray is found useful in Switzerland, Eckstein (page MA 20 R 5) tells us, for preserving eggs, cheese and dynamite. Lucky the shape of these articles differs so one won't get them mixed up when they all have similar metal overcoats.

Hydrogen in Chromium Plate

Frölich (page MA 20 L 8) claims that hydrogen in Cr plate decreases corrosion resistance and causes a type of staining, or "spotting-out" in service, and advocated heating to drive out hydrogen. However, he says it won't work over intermediate layers that also contain hydrogen, for the gas coming out of the layers beneath makes the Cr layer porous.

Scratches and Endurance Properties of Lead

Scratches on lead do not have much effect in reducing the endurance properties according to Chaston (page MA 33 R 7).

Insulate the Bottom of the Furnace

Wohlfahrt and Ell (page MA 12 R 3) say that the most advantage is gained from insulating the bottom of the hearth of an open hearth or electric steel melting furnace.

Hydrogen Fluoride in Chromium Plating

HF is better than H_2SO_4 in a chromium plating bath, according to Mueller and Drechsel (page MA 20 L 6). Better efficiency at room temperature, better throwing power, and wide range of current density for bright plating. And, according to Fröhlich (page MA 20 L 8) if your first attempt at Cr plating isn't good, you can best strip in by anodic attack in caustic soda, ready for re-plating.

Nickel Makes Enamel Stick Better

Good idea to put a nickel flash on steel to be enameled, makes the enamel stick better, says Hofstetter (page MA 20 R 8).

Pigs without Sows, Milk without Cows

Ford's English plant (page MA 2 R 7) is reported as producing cast iron pigs without sows. Not so remarkable when Henry is reported as planning to make milk without cows, too.

Flaky Steel

We don't hear as much about flaky steels as we did during the war, but the Russians are worrying about them. Neskuchaev (page MA 21 L 3) concludes that flakes are open spaces in the metal, lined with volatilized Fe or Ni, but that the spaces won't weld up completely on working.

Nut-Cracker Test for Cast Iron

Ludwik and Krystof (page MA 24 R 3) suggest a sort of nut-cracker test for cast iron, said to be more or less related to tensile strength, but cheaper to determine.

German vs. American Cast Iron Tests

Conversion factors for tests on standard German cast iron bars to the standard American ones are worked out by Heller and Jungbluth (page MA 22 R 7). The experimental factors differ somewhat from those obtained by mere mathematical conversion.

Oiliness

According to a couple of Jap mechanical engineers (page MA 22 R 8), lubrication depends not only on oils but on the bearing metal, i.e., that "oiliness" resides not only in the oil but in how it comports itself on a particular bearing surface.

Hydrogen and Tantalum

Moers (page MA 2 L 6) finds that unworked tantalum produced by thermal decomposition will not pick up hydrogen at temperatures at which wrought tantalum avidly absorbs it.

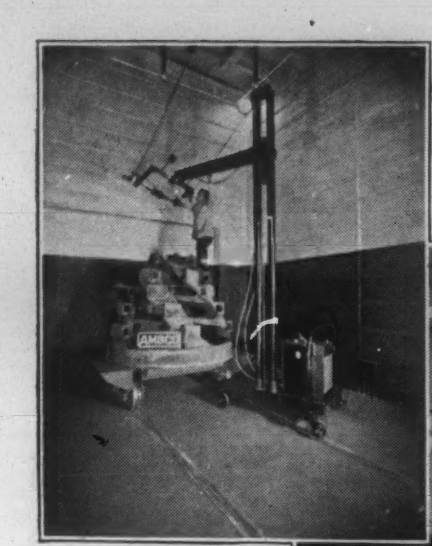
Electrolyses of Fused Sodium Hydroxide

Evidence is produced by Halla and Tompa (page MA 2 L 8) to show that the electrolyses of fused NaOH there is true solubility of metallic Na in the melt, as well as metal fog. Also that sodium hydride is formed.

Blast Furnace Practice and Linings

A British committee (page MA 2 R 3-5) reports on many details of blast furnace practice, and on blast furnace linings.

X-RAYED



Exposure room, showing X-ray tube stand — indicating flexibility of apparatus.

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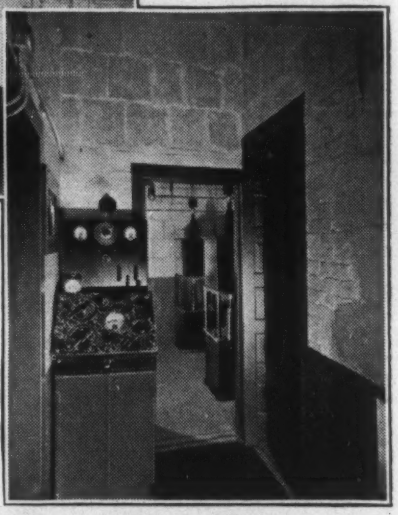
Exterior view — AMSCO X-ray Laboratory.



Control stand, looking toward machine room.

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The last word has not been said in more closely adapting metal compositions to definite service conditions. Neither is it impossible to improve standards of design, foundry procedure, and heat-treatments of alloy steel castings so that they will more efficiently and economically serve their intended purposes.

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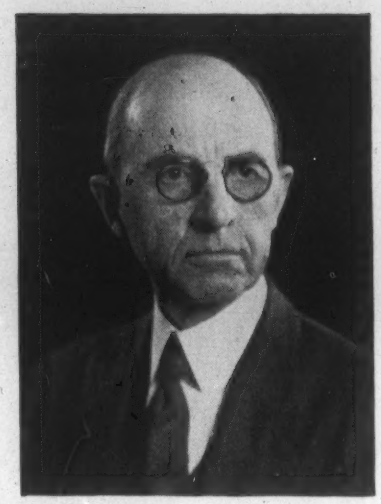
The Publishers Announce

that, commencing with the January issue of METALS & ALLOYS, the position of Editor will be occupied by Edwin F. Cone, who has had a broad experience in editorial work. For twenty years he was Associate Editor of The Iron Age, New York, N. Y., following technical and metallurgical developments in the iron, steel and metal industries. He has written many articles for The Iron Age and other journals, as well as papers before technical societies.

Previous to his editorial career, Mr. Cone was chemist and metallurgist in charge of the open hearth department, Thurlow Plant, American Steel Foundries, Chester, Pa., and, before that, chief chemist, Grasselli Chemical Company, Cleveland, Ohio. He is a graduate of Buchtel College, Akron, Ohio, and of the Case School of Applied Science, Cleveland, Ohio. He is a member of the American Institute of Mining and Metallurgical Engineers, the American Society for Testing Materials, The American Society for Metals, the American Foundrymen's Association and the Electrochemical Society.



Edwin F. Cone

Richard Rimbach

Richard Rimbach, who has been Editor for several years, will be Consulting Editor and Editor of the Current Metallurgical Abstracts, and will be located at the Pittsburgh office. Besides his recent editorial work, he had written technical articles and translated several books from the German including Siemens Konzern's "Beryllium and its Alloys," Tafel's "Theory and Practice of Roll Design" and Preuss-Berndt-v. Schwarz's "Metallography Simplified for Practical Use in Shop." He is Managing Editor of INSTRUMENTS, which he owns and which he will continue to publish in Pittsburgh.

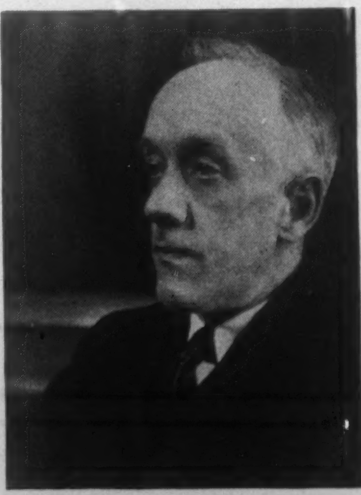
Mr. Rimbach is a graduate of the Massachusetts Institute of Technology and Harvard. In his early career he was metallurgist, Illinois Steel Company; metallurgist in charge of research, Standard Steel Car Company; rolling mill foreman, Jones & Laughlin Steel Corp.; research engineer, Union Switch & Signal Company and technical advisor, Bacharach Industrial Instrument Company.

He is a member of the American Society for Metals, American Iron and Steel Institute, American Electroplater's Society, American Society for Testing Materials, Institute of Metals (British), Society of Automotive Engineers, Verein deutscher Eisenhüttenleute and Verein für Materialprüfungen der Technik.

Dr. H. W. Gillett continues as Editorial Director of METALS & ALLOYS who, with the Editorial Advisory Board, will maintain the same high standards and policy already established. Dr. Gillett is well-known in the metallurgical and technical field through his contributions on technical subjects and his discussions before technical societies. He is the author of "Brass Furnace Practice in the U. S." (Bureau of Mines Bulletin 73); "Melting Brass in a Rocking Electric Furnace" (Bureau of Mines Bulletin 171); co-author with H. W. Mack of "Molybdenum, Cerium and Related Alloy Steels."

Since his graduation from Cornell University, Dr. Gillett has been chemist for Thomas A. Edison and A. D. Little, Inc.; manager, research department, Aluminum Castings Company; chief alloy chemist in charge, Ithaca Field Office, U. S. Bureau of Mines; chief, Division of Metallurgy, U. S. Bureau of Standards and director of Battelle Memorial Institute. At present he is chief technical advisor of the Institute.

Dr. Gillett is a member of several technical societies: American Chemical Society, The Electrochemical Society, American Society for Testing Materials, American Institute of Mining and Metallurgical Engineers, Institute of Metals (British), American Society for Metals, American Welding Society and American Foundrymen's Association.



H. W. Gillett

Ralph Reinhold

President

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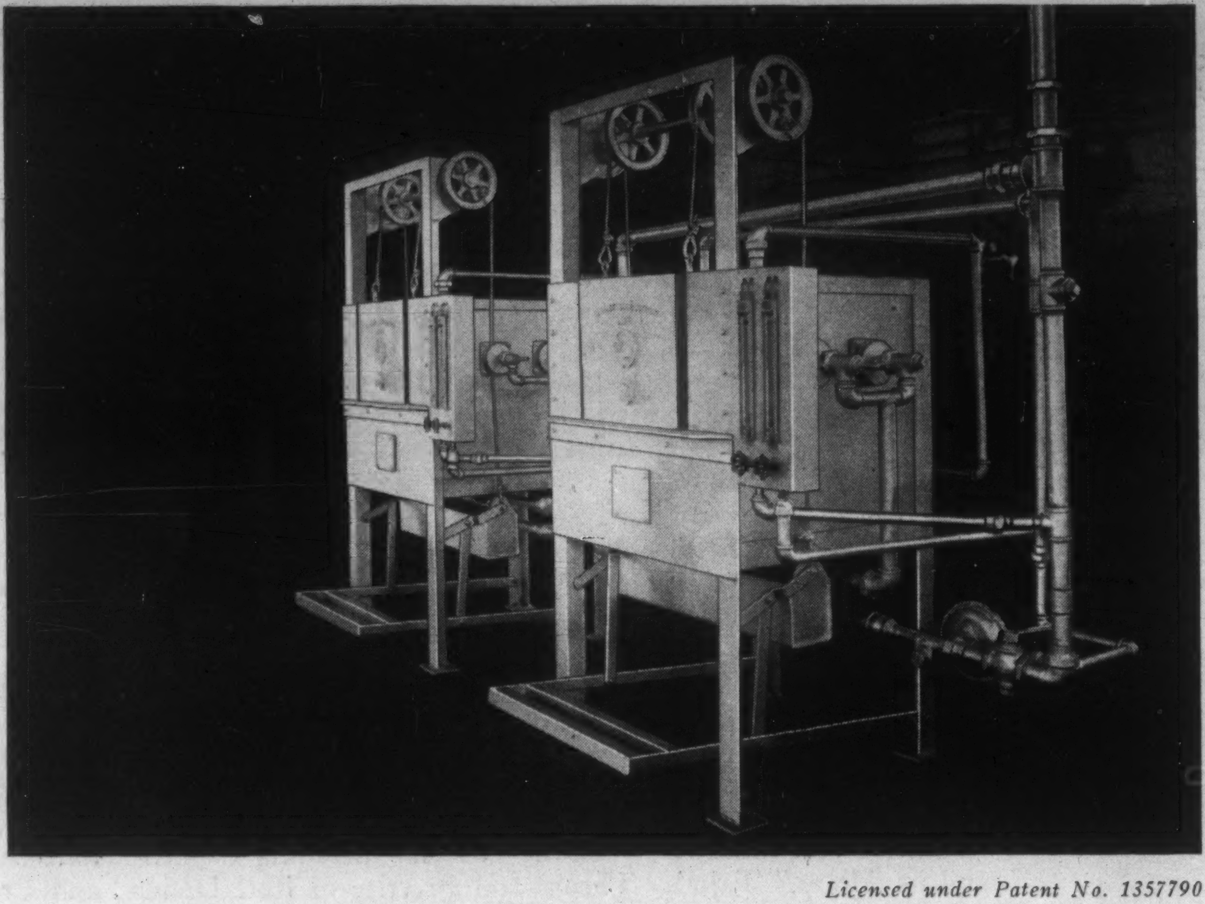

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EDITORIAL COMMENT

Science & Steel

UNDER THE TITLE "Some Applications of Science to the Making and Finishing of Steel," Dr. John Johnston, in the Robert Henry Thurston lecture, at the December meeting of the American Society of Mechanical Engineers, discussed both the past and the future.

The lecture was addressed to mechanical engineers and will be published in full by the A.S.M.E. It is of such interest to the metallurgist that we venture to utilize an abstract of some of its features as an editorial, even though in condensing and reflecting it, we lose much of the brilliance of the original. We hope this abstract will lead the metallurgical engineer to read the original when it is published.

Dr. Johnston pointed out that the steel industry has profited by the percolation into it of much science developed with no idea of its special application to that industry, such as Gibbs' phase rule and many other angles of physical chemistry. A decisive point in the development of industry came when the more forward-looking firms gave into the hands of research groups the definite commission to seek out existent principles of science, to find new ones and to apply all these principles, together with the new tools required in the application, to the betterment of the industry.

The need for such a step arose from the fact that formerly the user of steel had been chiefly benefited by progressive price reductions resulting from the application of mass production. For the present, however, relatively little more can be done in that direction in respect to semi-finished steel, for the cost of steel in the ingot or billet now resides largely in the cost of raw materials rather than in conversion costs, and such a high proportion of the raw material cost is in its transportation, that, in the face of the probable rising cost of transportation, further economies in steel making can do little more than tend to offset this cost.

Thus, the user cannot be helped by giving him his steel more cheaply and the aid extended to him by the steel maker will be rather along the lines of attainment of more uniform quality and of developing tailor-made quality steel especially produced to fill specific needs.

This does not mean the establishment of a host of new chemical specifications; quite the opposite. It means the finding out of what factors affect quality—whether the quality be conferred by alloying or by control of plain carbon steel—and then learning how to control those qualities.

In the evaluation of quality, care must be taken not to rely too much on conventional methods of test, for only those tests are of value that correlate with service.

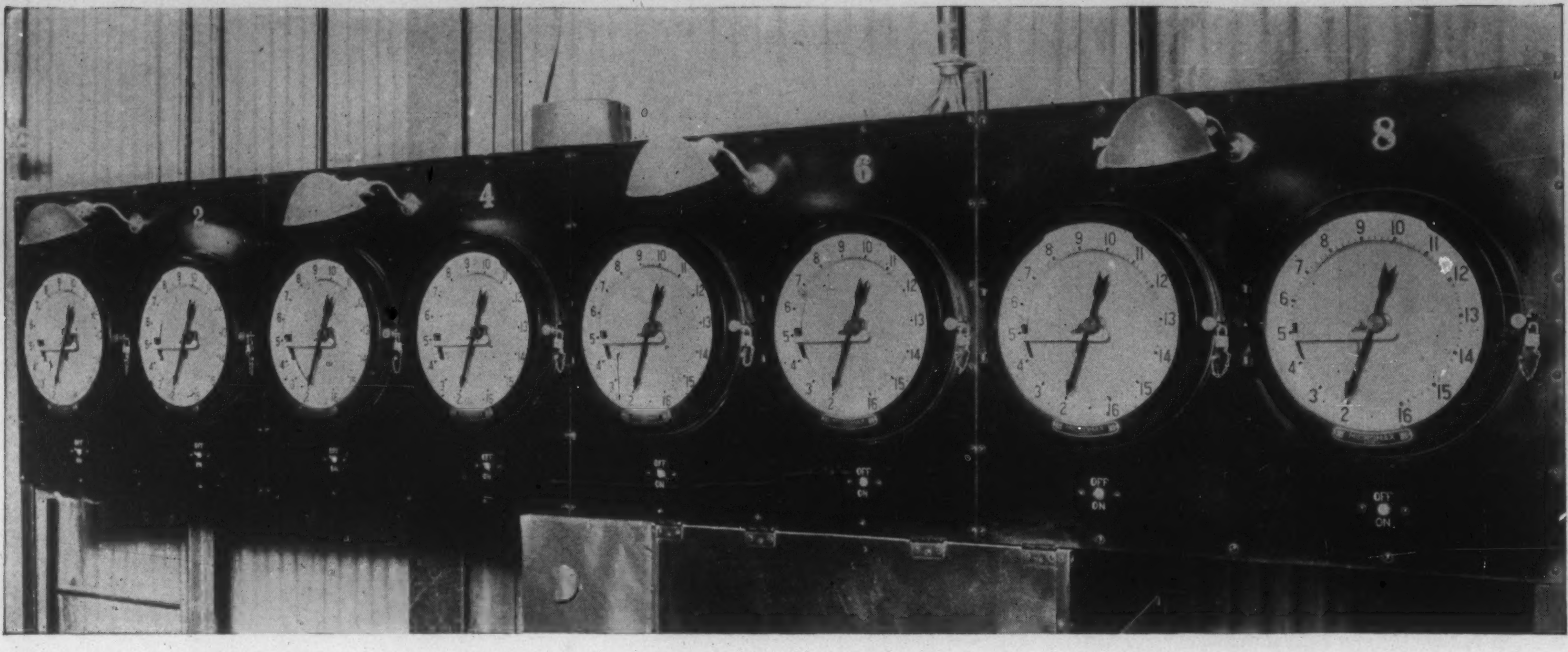
Dr. Johnston pleads for a loosening of unnecessary restrictions often imposed by the ordinary specifications and for greater emphasis on requirements relating to the detailed intimate structure of the steel without specifying just how this structure shall be obtained. To drive home his point he comments that Bessemer, open-hearth and electric steels are different not merely because they are made in apparently different ways but rather because in the ordinary methods of operation the steels differ in respect to minor constituents such as oxygen and nitrogen and that if methods of handling are evolved that remove or correct for those constituents, the products, if finished to be alike in detailed structure, will be indistinguishable and equivalent. Again, instead of classing phosphorus as a nuisance element and taking it down to a low limit at the expense of a severely oxidizing treatment whose effects in turn may be hard to repair, phosphorus may well be considered as a hardening element similar to carbon, but some three and a half times as potent.

The effect of alloying elements, in low alloy steels, is chiefly in influencing the transformation rate and thus introducing ease in accomplishing a desired end in heat-treatment. This and the control of grain size by regulating the slag and applying so-called deoxidation methods which allow adjustment of the amount and distribution of submicroscopic non-metallic material—as important in modern alloying as the alloying elements themselves—allow a close approach to exact control of the real composition (rather than that shown by what chemical analysis it is feasible to use in control), and hence of the detailed structure. With more complete understanding of these factors by the steel maker the user could specify what the steel is to do, and the maker could meet the requirements by choosing the most feasible and economical method of producing such a steel, unhampered by chemical requirements or traditional physical tests not pertinent to the features the user actually needs.

To produce and apply the information required before this goal can be reached will take many years of effort by specialists in many sciences (for example, in the development of better refractories), all working toward that goal, but the work is so interesting and the goal so worth while that progress will be more rapid than ever before.

H. W. GILLETT.

(Additional Comment on page 30)



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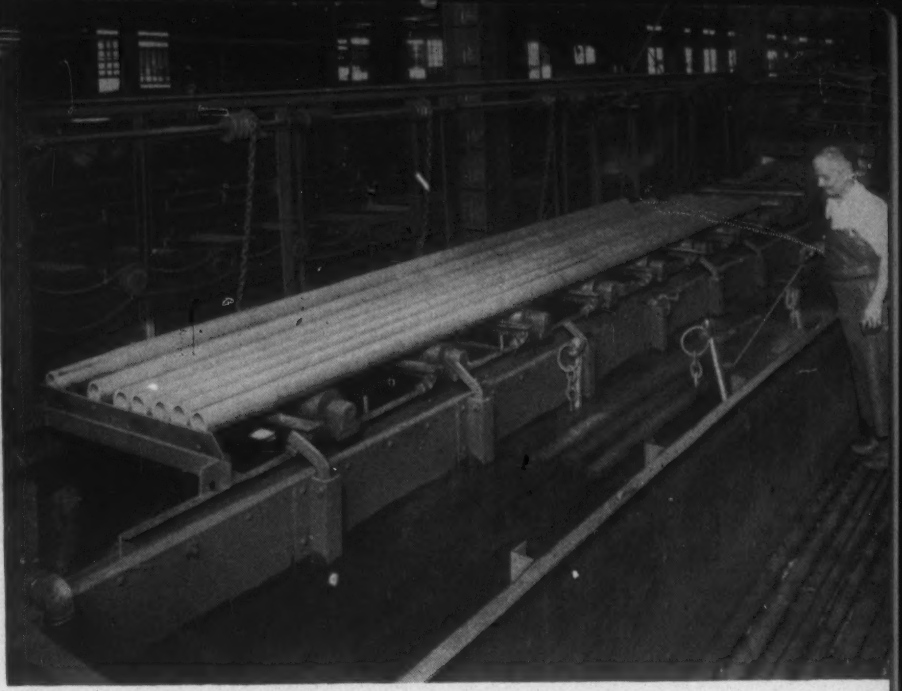


Continuous Annealing and Cooling Bath for Tubing.

THIS article was written in response to a suggestion made by H. A. Anderson of the Editorial Advisory Board that in practical work he often needed information that would help in laying out proper annealing practice for the common copper-base alloys, but that there was no convenient assembly of such information for reference. At the request of the Copper & Brass Research Association, Mr. Pratt was persuaded to set down the information in this article.

ANNEALING of COPPER ALLOYS

By R. S. Pratt*

THE RAPID development of the metal fabricating industry in recent years has made it necessary to control carefully the quality of the metal used. This has required the producers of the stock to study the annealing operations particularly among the factors involved, in order to meet the demands. More recently the fabricators have found it advisable to control their own annealing processes so as to take full advantage of the improved quality of metal. This gradual progress in the industry is illustrated by the A.S.T.M. Specifications for Sheet High Brass (B36-33).[1] When this specification was first written, it was thought necessary to provide for only 3 grades or tempers of annealed sheet. Within the last 2 years, this specification has been revised, increasing the number of grades of annealed sheet to five. The general trend in the use of sheet brass has been toward a finer grain size and lighter annealing temperature than was formerly considered advisable. In the last 10 years the average grain size of brass sheet for fabricating purposes has steadily decreased to meet the customer's requirements.

The problem of annealing copper alloys is one which has engaged the interest of investigators in many ways. A great deal of time has been spent on annealing problems but relatively little concrete information as to temperature has been published.[2] Undoubtedly this is due to the fact that the object of annealing varies considerably depending on what it is desired to accomplish in the subsequent operations. Primarily, there are two objects to be accomplished; that is, relief of internal stresses and recrystallization or softening of the metal. There are, however, many degrees to which the softening may be carried, depending on the extent to which the metal must be further cold worked and the type of finished surface required.

Let us consider the physical changes which occur in a piece of cold worked single solid solution alloy, as it is gradually heated above room temperature. The first change that occurs with which we are concerned is the relief of internal stresses which have been developed in the cold working operation. This starts at temperatures roughly 50° to 100° C. below the recrystallization temperature, but it is not complete until the metal is recrystallized. Commercially, time is an important factor in relief of stress and it is possible to reduce the stresses sufficiently to remove their injurious effects, without recrystallization or softening of the metal. Recrystallization consists of the more or less gradual transformation of the distorted cold worked grains into a mass of small equiaxed grains, free from internal stress. These new grains are softer and more ductile, which results in the decrease in tensile strength and increase in elongation characteristic of this change. As the temperature is gradually increased, the grains grow slowly. Metal cooled from this range will be capable of withstanding a limited amount of cold working and will finish with a smooth surface. Shallow cups, for instance, made from such material may be readily polished with a minimum amount of buffing. As the temperature is further increased the grains grow more rapidly, and the tensile strength is further reduced and the ductility increased. The first portion of this change, that is, grain growth and drop in tensile strength continues, in single solid solution alloys, until the melting point is reached, but the development of coarse grain is in some cases accompanied by a decrease in ductility. In so far as the ductility does increase, the metal is more readily cold worked, but the corresponding increase in grain size results in an increasing roughness of surface as the temperature is increased. In obtaining metal for fabricating purposes, it is often necessary to compromise between the amount of cold working on the one hand and ease of polishing on the other. This is one of the reasons why it is impossible to state exactly the temperature at which any given alloy should be annealed.

In studying the effect of annealing, it is desirable to determine the temperature at which softening first takes place, the temperature at which maximum ductility occurs and the relation of the temperature to the various properties of the sheet. There are several tests by which the degree of annealing may be gaged. It is considered more or less standard practice to determine the tensile strength, elongation and grain size of the annealed copper alloys in order to obtain a true picture of the condition of the metal and its suitability for further cold working operations. In rod and wire samples, reduction of area is also of great help in this respect, but unfortunately, it cannot readily be applied to sheet metal and tubing. In commercial practice in order to save time, there are a number of hardness tests, and ductility tests, which are valuable.[13-28] It is unfortunate that these hardness and ductility tests are rather limited in their application to certain types of material.

---

* Metallurgical Department, Bridgeport Brass Company.

In Fig. 1 are shown annealing curves which illustrate the relation of temperature to the tensile strength, elongation and grain size in some high brass wire. From these curves, it is seen that the metal softens most rapidly and is recrystallized, between 250° and 300° C. The greatest ductility is obtained at the highest temperature, approximately 750° C., and the lowest tensile strength is found at the same temperature. The grain size increases with increase in temperature and the rate of increase also increases with the temperature. It is worthy of note that high brass is produced commercially having properties in accordance with temperatures all the way from 300° to 750° C.

The earliest data on annealing of copper alloys were published by Beilby[3] in England and Grard[4] in France. These papers were soon followed by those of Bengough and Hudson.[5, 6] These workers reported on the effect of temperatures on some copper-zinc alloys and produced indications that the annealing operation is more complicated than might be supposed.

If the annealing curve in Fig. 1 could be applied generally to all high brass, the annealing problem would be relatively simple. A paper published by Mathewson and Phillips in 1919,[10] showed that it is complicated by variations in the amount of rolling prior to the annealing operation. This paper also showed that time was an important factor in annealing, particularly at the lower temperature. Soon after the publication of this paper several others appeared along the same lines,[14, 15, 16] showing the effect of the previous treatment on the annealing characteristics of various alloys, and the result of this work, together with some original work of their own, culminated in the publication by Jeffries and Archer[19] of the laws of grain growth. No full appreciation of annealing in solid solution alloys can be obtained without a knowledge of the points brought out by these various writers.

The effect of variation in cold work before annealing is shown in Fig. 2 for samples of the same alloy as in Fig. 1 which had received varying degrees of cold working after the same annealing operation. The increased amount of cold work as shown by these curves raises the initial tensile strength, lowers the temperature of recrystallization slightly and, after grain growth has started, increases the tensile strength and lowers the elongation. The effect of the varying amount of cold working is also noticeable in the grain sizes after recrystallization. The metal which has received the least cold working recrystallizes with the coarsest grain size. This difference is particularly noticed at the lower annealing temperatures.[22] These points were first shown very clearly by Bassett and Davis[15] in 1919 in some Brinell tests and grain size measurements of annealed cartridge brass.

It has also been shown that the annealing temperature before rolling is a factor in the property of the alloy after rolling and annealing.[14, 16] These effects are brought out in the curves in Fig. 3 in which a comparison of the annealing characteristics of high brass wires which have been given anneals prior to drawing 40% hard such as to produce grain sizes of 0.035 mm. and 0.080 mm. is shown. The effect of this variation in grain size is not particularly great in the condition of the material after drawing, but it is noticeable that this small difference persists after annealing. The finer grained material produced the harder metal after drawing, and its recrystallization point is lower.[25] After recrystallization the metal with the finer grain size showed the higher tensile strength, lower elongation and finer grain size. In all these curves the increase in tensile strength on annealing at temperatures below the recrystallization point is apparent, and also it is apparent that the increase shown is greater in the harder material. Both these factors have been noticed previously in tests on cartridge brass[15] and the general increase has been reported in tests on nickel silver. In the richer copper alloys, this effect has not been so generally noticed.

The various effects of the previous treatments to which the alloy is subjected before annealing are not so confusing as might first be considered if it is remembered that any combination of preliminary treatment which tends to harden the metal, that is, either a lower annealing temperature or a greater amount of cold work also tends to have the same effect after annealing and that the harder the metal is before annealing, the lower the temperature of recrystallization will be.

The combined effect of these variables is of sufficient extent to make itself felt in many annealing operations. In regular mill practice it has been found necessary to control the mill schedule of rolling or drawing with relation to the annealing operation in order to obtain the desired grain size and physical properties in the finished products. An interesting example of the effect of the annealing prior to final annealing in a fabricated article was recently encountered. The article was specified to be finished with a very light anneal. Some of the sheets from which the part was fabricated were annealed at a higher temperature than normal, or than was specified, resulting in a coarse grain size. These parts were mixed in production with parts made from properly annealed sheets. When finally annealed at a temperature such as to give recrystallization in the properly processed part it was found that the parts made from the coarse grain sheet were not recrystallized and were, therefore, too hard. This is perhaps an extreme example of the effect of preliminary treatment, but the point is brought out to impress the need for careful consideration of preliminary operations to which the alloy may have been subjected in order to determine the proper annealing temperature required to obtain specified physical properties.

All of these points apply to material of the same specified composition. The differences in composition within the commercial control limits for any one alloy are not, generally speaking, serious factors in obtaining uniform results on annealing. It is, however, necessary in some materials to watch closely the impurities present. The effect of iron on high brass in this connection is well known[29] and precautions are generally taken by the producers and the purchasers through specifications to keep the impurities at a low value. Iron is effective in retarding the grain growth

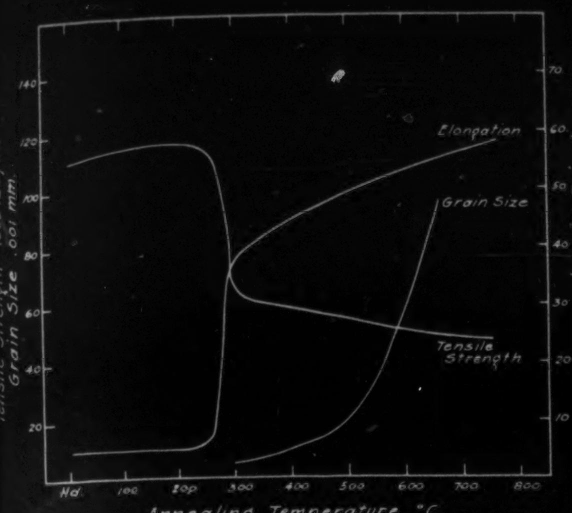


Fig. 1. Characteristic Annealing Curve High Brass Wire Drawn 63% Hd. Annealed 1 hour at indicated temperature.

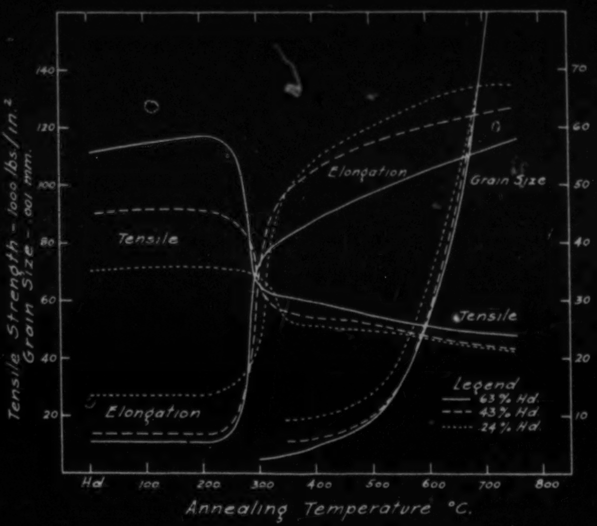


Fig. 2. Effect of Varying Amounts of Cold Working on Annealing Characteristics of High Brass Wire.

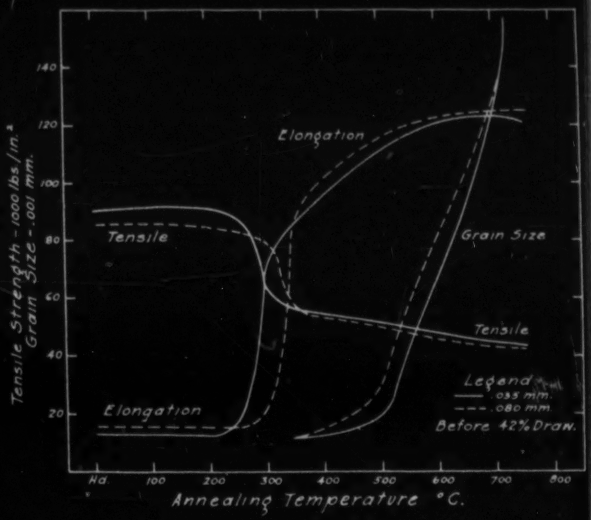


Fig. 3. Effect of Varying Anneals Before Drawing on Annealing Characteristics of High Brass Wire.

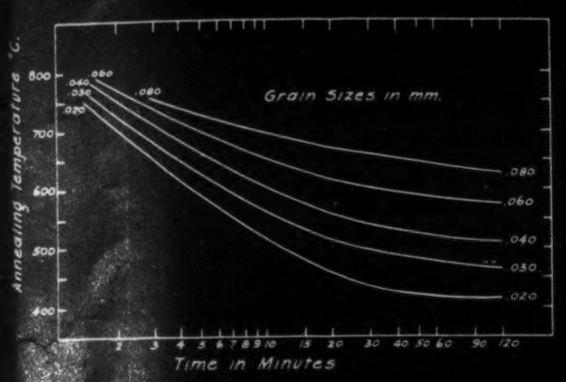


Fig. 4. Effect of Time on Annealing High Brass Sheet Gage .050 inches.

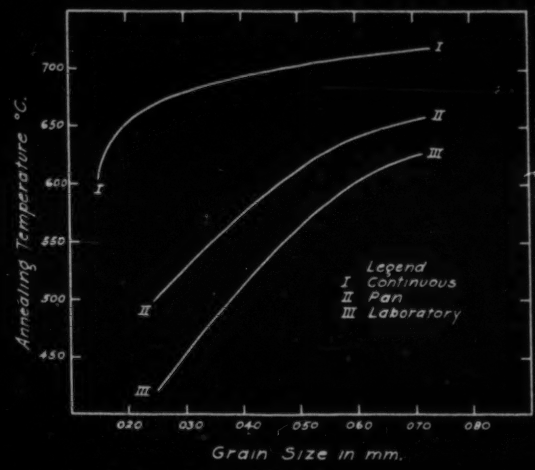


Fig. 5. Grain Size and Temperature Relations in Various Sizes of Annealing Operations.

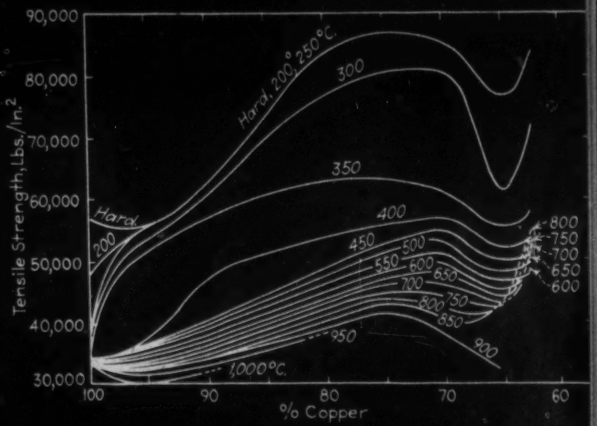


Fig. 6. Tensile Strength of Annealed Copper Zinc Alloys Sheet Cold Rolled 5 B & S Gage Nos. Hard and Annealed 30 min. at indicated temperatures (Bassett & Davis).

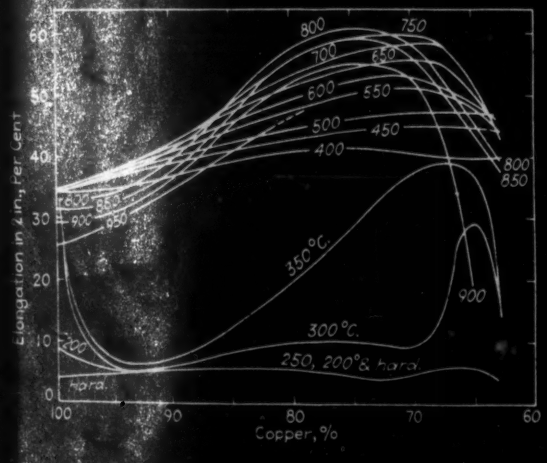


Fig. 7. Percentage Elongation in 2 in. of Copper-Zinc Alloy Sheet, Cold Rolled 5 B & S Nos. Hard and Annealed 30 min. at indicated temperatures (Bassett & Davis).

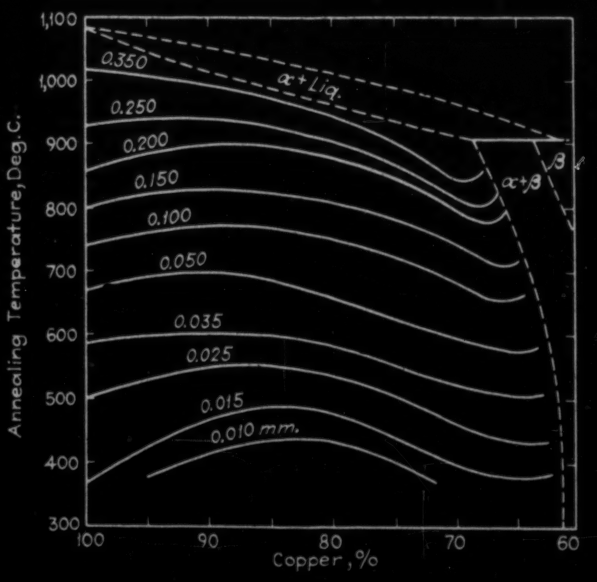


Fig. 8. Grain Size of Copper-Zinc Alloys Produced by 30 min. Annealing of Cold Rolled Sheet 5 B & S Nos. hard. (Bassett & Davis).

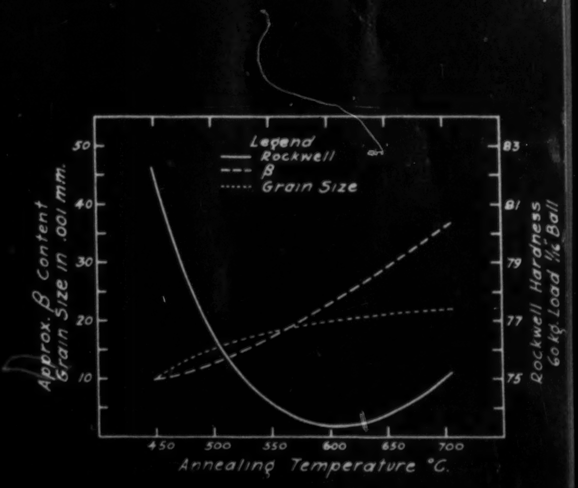


Fig. 9. Effect of 30 min. Anneal and Air cooling on Structure and Hardness of 60-40 Copper-Zinc Alloy.

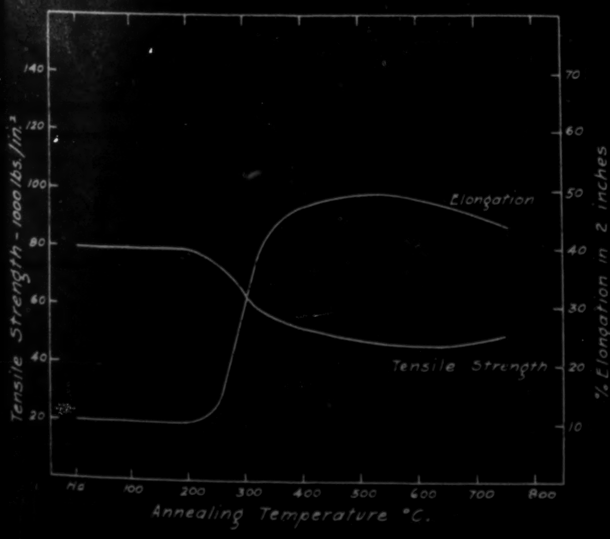


Fig. 10. Annealing Characteristics of Leaded Muntz Metal Rod Drawn 35% Hd. and Annealed 1 hour at indicated temperatures and air cooled.

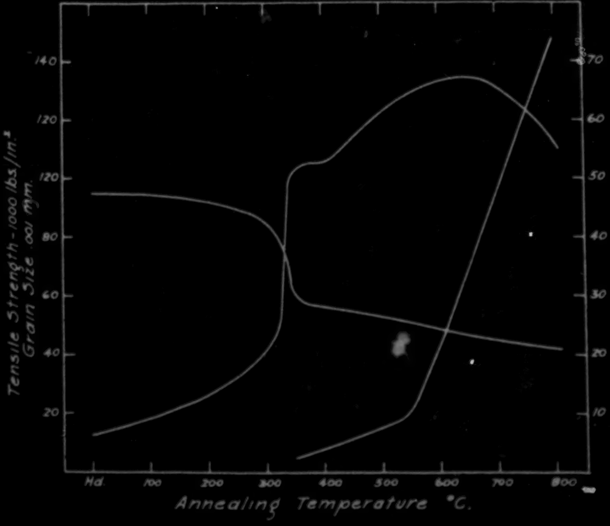


Fig. 11. Annealing Characteristics of 5.5% Tin Phosphor Bronze Cold Rolled 50% and Annealed 1 hour at indicated temperature.

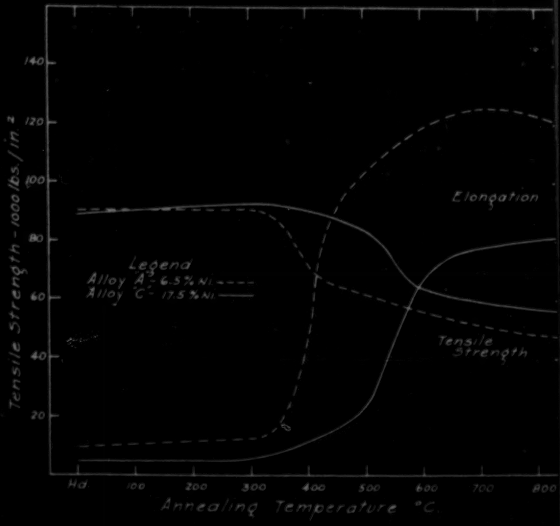


Fig. 12. Annealing Characteristics of Nickel Silver Sheet Cold Rolled 40 to 45% and Annealed at indicated temperature for ½ hour (Price & Davidson).

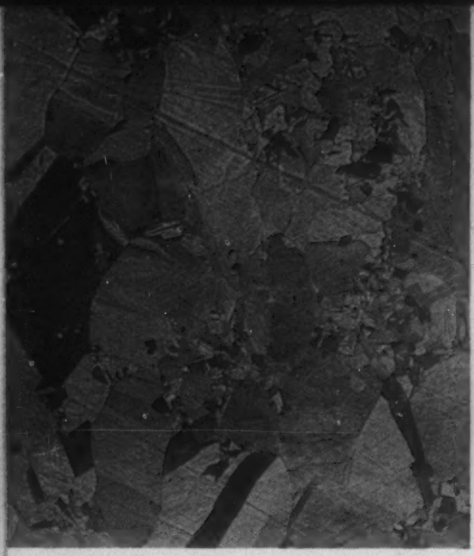


Fig. 13. Partial Recrystallization

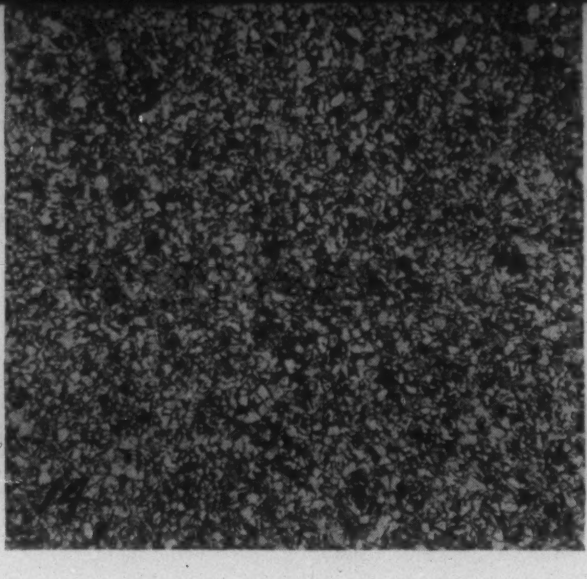


Fig. 14. Grain Size—0.010 mm.

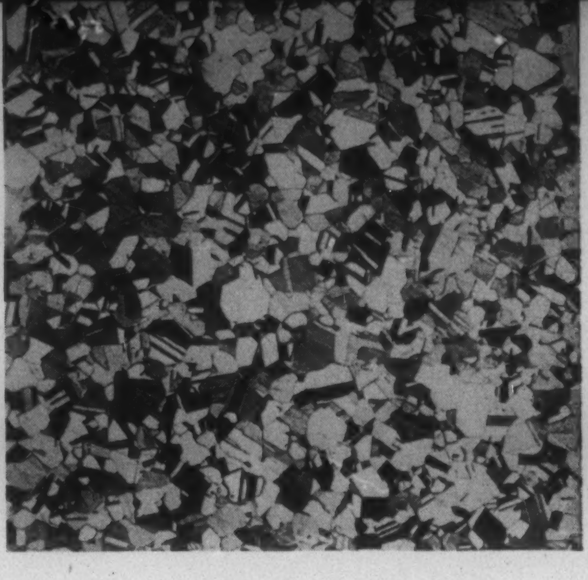


Fig. 15. Grain Size—0.035 mm.

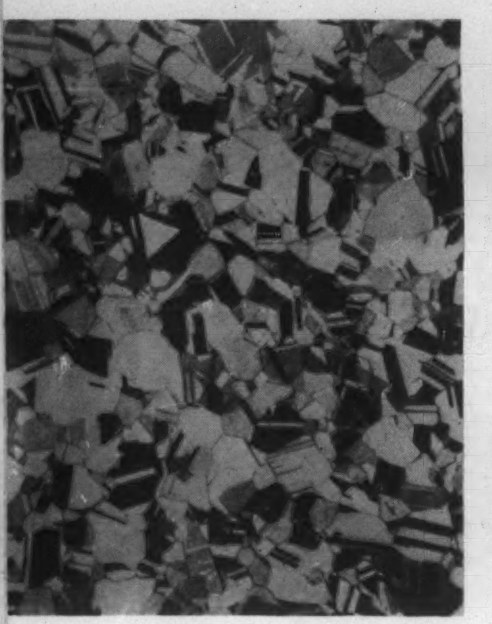


Fig. 16. Grain Size—0.045 mm.

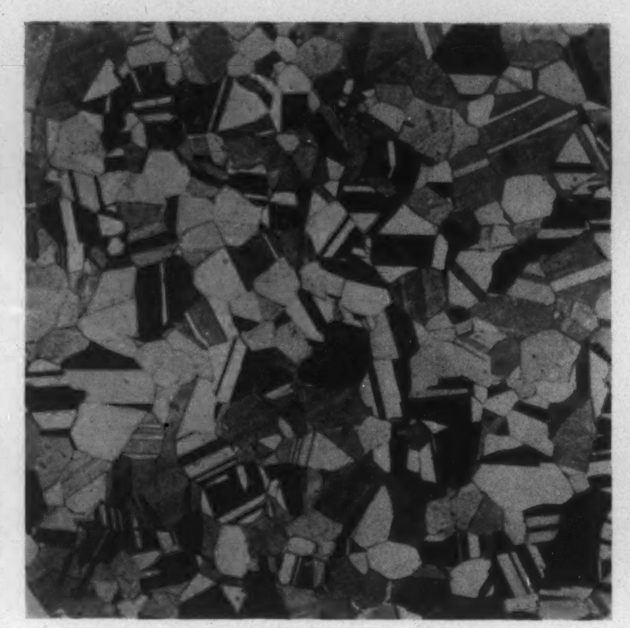


Fig. 17. Grain Size—0.065 mm.

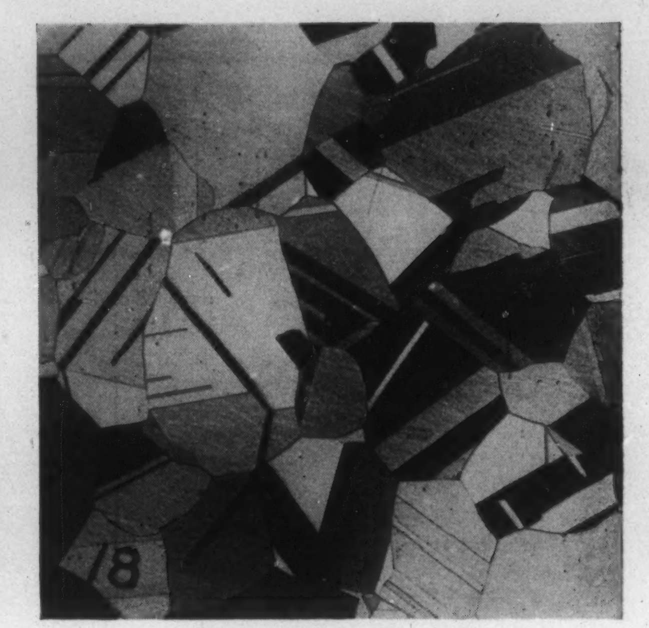


Fig. 18. Grain Size—0.150 mm.

HIGH BRASS. ETCHED IN NH_4OH and H_2O_2. MAGNIFICATION 75X

in all of the softer solid solution alloys, and in this way may cause difficulties in obtaining the desired physical properties. Its presence is less serious in the harder copper alloys and in some cases it is added intentionally to increase the hardness of the alloy. With the single exception of iron, however, the usual impurity and mixture variations encountered in any given commercial alloy are not such as to give trouble.

Of the various physical tests mentioned above, the determination of grain size is perhaps the most useful indication of the physical properties of the metal. Much the same data can be obtained from the tensile strength, but the grain size determination[11, 23] is so much cheaper and easier to obtain that it is used generally in routine work. For investigation and research the combination of tensile test and microscopic examination gives the most complete story, not only of the single solid solution copper alloys, but also of two phase alloys such as Muntz metal and some of the nickel silver alloys. The microscopic examination is essential in testing material annealed near the recrystallization point to determine the extent of recrystallization. To illustrate this point the micro-photographs in Figs. 13-18 show the various grain structures obtained on annealing α-solid solution copper alloys. Fig. 13 shows partial recrystallization, such as might occur when annealing at about [illegible]° C., a rather coarse grained high brass moderately cold worked. As pointed out previously, the new grains are coarser than would obtain if the previous structure had been finer grained and more severely cold worked. Fig. 14 shows the finer grained structure which obtains on recrystallization of the finer grained and more severely worked material. Figs. 15, 16, 17 and 18 show the results of higher annealing temperatures. With the exception of Fig. 13, these photographs are taken from the A.S.T.M. Standards E2-30[23] for Micrographic Work.

There is one other factor in commercial annealing which is of vital importance and that is time. The annealing time cycle is divided into two parts; namely, the time required to heat up to temperature and the time held at temperature. In commercial annealing, it is probable that the time required to heat up to temperature is fully as important if not more important, than the time held at temperature. In the curves in Figs. 1, 2 and 3, the annealing time totals one hour of which about 45 to 50 minutes is the time at temperature. In commercial annealing the total time varies from a few seconds in the case of the Snead tube annealer to 2 hours or more in the large batch annealing furnaces. In Fig. 4 the effect of these various total annealing times is shown for high brass which has all received the same preliminary treatment in rolling to 0.050" gage. The time of anneal has been plotted to a logarithmic scale, simply to open up that portion of the scale in the shorter time periods. In these tests, the annealing conditions were such that the time to attain temperature was a small portion of the total time and for any given temperature a constant value. For this reason, these curves are indications of the effect of actual time at temperature. The importance of this factor is obvious, particularly in obtaining the finer grain size. As the grain size increases above 0.080 mm., the curve flattens out and the

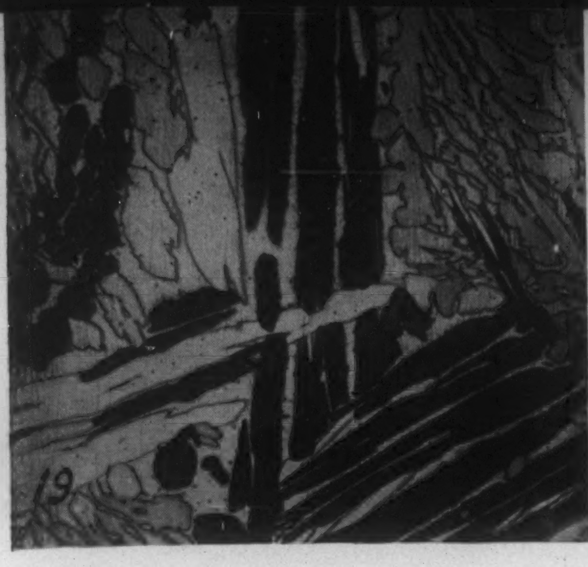


Fig. 19.

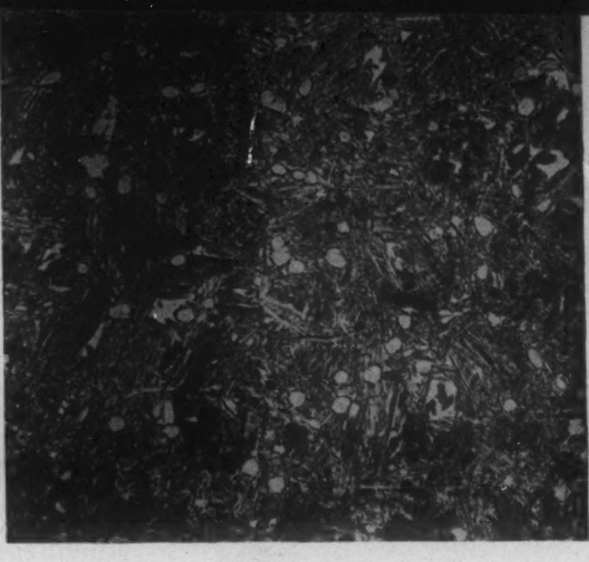


Fig. 20.

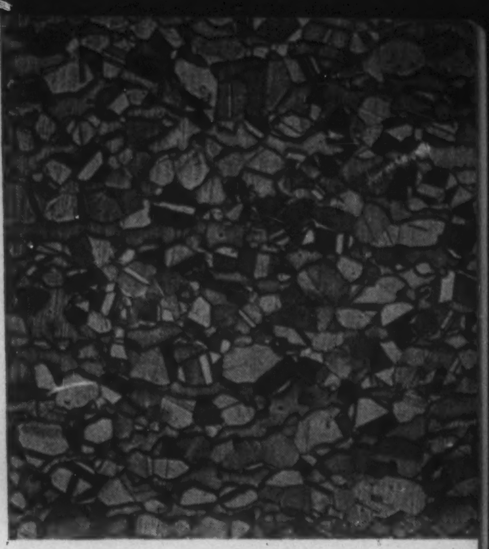


Fig. 21.

MUNTZ METAL. ETCHED IN NH_4OH AND H_2O_2. MAGNIFICATION 75X

effect of time is of less importance. This fact conforms with one of the laws of grain growth which states that "the higher the temperature, the more rapid the grain growth."

As indicated above, the annealing equipment is a factor in the relation of grain size and temperature. This is apparent when the annealing temperature required to develop a given grain size is compared for various types of annealing equipment. Such a comparison is shown in Fig. 5. The variation shown between curves 1 and 2 is due primarily to the difference in time at temperature, due in turn to the increased time of heating required for the larger volume of metal involved. The difference between curves 2 and 3 are due largely to the fact that the indicated muffle temperature due to the location of the thermocouple, is not identical to that ultimately reached by the metal. These data are admittedly approximate, being based on average conditions, rather than on any specific tests, but they are shown to bring out a point which is very definite and well known. The spread between indicated and actual muffle and metal temperatures is of real importance. In new annealing equipment, it is necessary to determine the relation of temperature indicated and actual temperature attained by the metal, as well as the time required to attain this temperature with a given mass of material. When these points are known, the application of the principles of the laws of grain growth will make possible intelligently controlled annealing.

It is to be hoped that the discussion of these facts does not confuse the reader. It is our belief that actual annealing is impossible without a clear understanding of these variables which affect it to a greater or lesser degree.

The amount of detailed data available on annealing is, generally speaking, proportional to the need for it and, therefore, the wealth of data on alloys which are customarily produced and used in an annealed condition is understandable, as is the dearth of data on alloys which are customarily used in the hard rolled condition. However, it is on these rarer occasions when one is required to anneal the latter alloys that the information is most difficult to obtain and therefore most desirable.

Perhaps the most detailed work published in this connection is that by Bassett and Davis in 1927,[26] although others have covered portions of the same field.[13] This work was done on sheet metal and reports among other data on the copper-zinc alloys, the effect of annealing temperatures on the tensile strength, elongation, and grain size of the various copper-zinc alloys. These data are shown in Figs. 6, 7 and 8, which are taken from that paper. There are probably no better data in existence covering these alloys than those available in these curves. As a matter of fact, there are, as far as we know, no similar data available on any of the other series of copper alloys.

There are several commercial brass alloys which are not covered by these curves.[8, 18] They are the alloys customarily produced in the form of rod and tubing, such as the Muntz metal alloys, from which are made free-cutting rod, cold heading rod, forging rod, Naval brass rod and some pipe and tubing. Figs. 9 and 10 show the annealing characteristics of these alloys. They differ notably from other characteristic curves shown here in that the higher temperatures tend to increase the hardness and strength of the alloy.

As indicated by the curves in Fig. 9, the grain size does not bear as close a relation to the hardness of the alloy as in the single α-solid solution alloys, due to the presence of the additional β constituent. The amount of β present varies with the exact mixtures, the annealing temperature and the rate of cooling.[12] It is therefore not possible to use grain size measurements alone in controlling or ascertaining the annealing conditions to which the stock may have been subjected.

In Figs. 19-21 are shown characteristic structures of Muntz metal alloys. Fig. 19 is that of a 60-40 copper zinc alloy heated sufficiently to develop the coarse grained β structure and then cooled slowly, allowing the separation of finger-like α-crystals. Fig. 20 shows the structure of a similar alloy after hot forging. In this case the β grains developed were finer and the α-structure developed on cooling was correspondingly finer. Fig. 21 is that of a normally cold worked and annealed Muntz metal in which the β has been reduced to about the minimum possible in accordance with the copper content. This structure represents the most ductile condition obtainable in Muntz metal alloys.

It should be noted that commercially, reference to the equilibrium diagram[2, 27] for copper zinc alloys is not sufficient for determining the probable ratio of alpha and beta constituents, for much material is made which has not been annealed for a sufficient length of time to reach equilibrium conditions. A great deal of commercial rod, for instance, is made simply by extruding and drawing to size, and no annealing operation of sufficient time is given to allow equilibrium conditions to be obtained. This has the general effect of producing rod of higher β content than equilibrium conditions require. Subsequent commercial annealing operations sufficient to soften the rod are likewise not usually long enough to produce equilibrium, although recrystallization and softening may be obtained

Pan Annealing Furnace for Coiled Sheet.

throughout a wide range of temperature. Considerable care must be taken if it is desired to obtain material of maximum ductility. Generally speaking, this is best done by prolonged treatment at moderately low temperatures; that is at temperatures sufficiently low to prevent the development of β and sufficient time to absorb such β as may be present above the equilibrium requirements for the particular annealing temperature used.

Relatively little phosphor bronze is produced in the annealed condition for further cold working and annealing operations. Probably for this reason there are little data available in the literature on its annealing characteristics.[7] The number of copper-tin alloys is limited because of the limited solubility of tin in copper in comparison with zinc in copper. Fig. 11 shows the annealing characteristics of the 5.5% tin alloy. It may be noted that the recrystallization point of this material is lower than in the copper-zinc alloy of the same concentration and for the same initial conditions it occurs somewhat less abruptly. Its elongation is about equal to that of high brass and represents about the maximum value obtained in the copper-tin alloys. These alloys are normally deoxidized with phosphorus, hence the name phosphor bronze, and the small amount of excess left in the alloy is an important factor in the properties. Phosphorus is much more effective in hardening copper-tin alloys than corresponding additions of tin. Some manufacturers plan to leave from 0.2 to 0.4% phosphorus in the alloy, producing a harder material thereby than would normally obtain with the amount of tin used.

The nickel-silver alloys are copper-zinc alloys in which some of the zinc is replaced by nickel. A great variety of alloys of this type have been made. The literature contains a number of references to their different properties.[20] The curves in Fig. 12 taken from data by Price and Davidson show annealing characteristics of the 7 and 18% nickel alloys.[17] The presence of the nickel raises the recrystallization point,[9] particularly in the alloys of higher nickel content. The tensile strength is increased over that of high brass and with the higher nickel content the elongation materially decreases.

There are a large number of copper-nickel alloys. Nickel and copper form a solid solution throughout the entire range of alloys and a wide range of commercial products is made from them. Of those which may be considered copper alloys, the ones containing from 15 to 30% of nickel are most important commercially. As in the nickel-silver alloys, the addition of nickel increases the tensile strength, raises the recrystallization point and annealing range and lowers the elongation.[21]

In the accompanying table are shown the recrystallization range and annealing temperatures required to produce the best physical properties of some of the standard commercial copper alloys and a few of the more recent proprietary alloys. This table is by no means complete but should be of assistance to those who are commercially annealing copper alloys.

No reference is made here to the other heat treatments to which copper alloys are sometimes exposed. Annealing to produce homogenization is seldom required in fabricated alloys, although it is of vital importance in producing some alloys. Some of the new alloys commonly known as "precipitation hardening" alloys require a double heat treatment to produce the results claimed by the manufacturers.

No discussion on the annealing of copper alloys

(Continued on page 10)

Table I

Trade Name	Composition Cu	Zn	Sn	Si	Misc.	Recrystallization Range ° C.	Commercial Annealing Range ° C.	Reference
Gilding Metal	95.0	5.0	....	....	....	350–400	400–700	26
Commercial Bronze	90.0	10.0	....	....	....	350–400	400–700	26
Rich Low Brass	85.0	15.0	....	....	....	300–400	400–700	26
Low Brass	80.0	20.0	....	....	....	250–400	400–800	26
Brazing Brass	75.0	25.0	....	....	....	250–400	400–800	26
Cartridge Brass	70.0	30.0	....	....	....	250–350	400–750	26
Common High Brass	66.0	34.0	....	....	....	250–350	400–700	26
Muntz Metal	60.0	40.0	....	....	....	200–350	450–650	Author
Free Turning Rod	61.0	36.0	....	....	Pb 3.0	200–350	450–650	Author
Forging Rod	60.0	38.0	....	....	2.0	200–350	450–650	Author
Admiralty Metal	70.0	29.0	1.0	....	....	250–400	400–700	Author
Naval Brass Rod	60.0	39.25	0.75	....	....	200–350	450–650	Author
Signal Bronze	98.5	....	1.5	0.01	....	250–400	400–800	Author
Phosphor Bronze	96.0	....	3.75	....	Phos. .30	250–400	400–800	Author
Phosphor Bronze	94.5	....	5.5	....	.15	250–400	400–800	Author
Phosphor Bronze	92.0	....	8.0	....	.15	300–400	400–800	Author
Nickel Silver	65.0	28.0	....	....	Ni 7.0	300–450	500–800	17
Nickel Silver	65.0	17.0	....	....	18.0	450–600	600–900	17
Aluminum Bronze	93.0	....	....	....	Al 7.0	300–450	550–750	31
Cupro Nickel	80.0	....	....	....	Ni 20.0	450–500	550–900	21
Adnic	70.0	....	1.0	....	29.0	550–600	650–800	30
Everdur	96.0	....	....	1.0	Mn 3.0	250–400	400–800	....
Herculoy	94.75	1.5	0.5	3.25	....	300–400	550–750	29
Olympic	....	....	....	....	....	....	450–750	Trade Paper
Duronze II	...	...	....	....	....	250–400	400–800	Author
Duronze I	....	....	....	....	....	250–400	400–800	Author

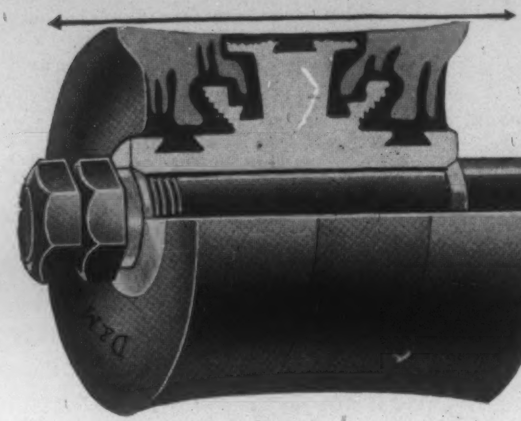


Fig. 1.

CENTRIFUGALLY CAST ELECTRIC CAST IRON PUMP PISTON CORES

by A. E. Falk*

SLUSH PUMPS used in oil well drilling nowadays requires a high-quality piston. The working surface of the piston is rubber, vulcanized onto a cast iron piston core. When shallow wells were the rule, the pumps operated at but 500 to 1000 lbs./in.^{2} pressure, and sand cast cupola iron piston cores were considered adequate. But with the advent of much deeper wells, pump pressures rose to 3000-4000 lbs./in.^{2} and the piston cores were no longer satisfactory. The tremendous load carried by the core under these high pressures caused many of the cupola iron cores to crack. When this occurred the cutting action of the fluid soon cut out the core and rod.

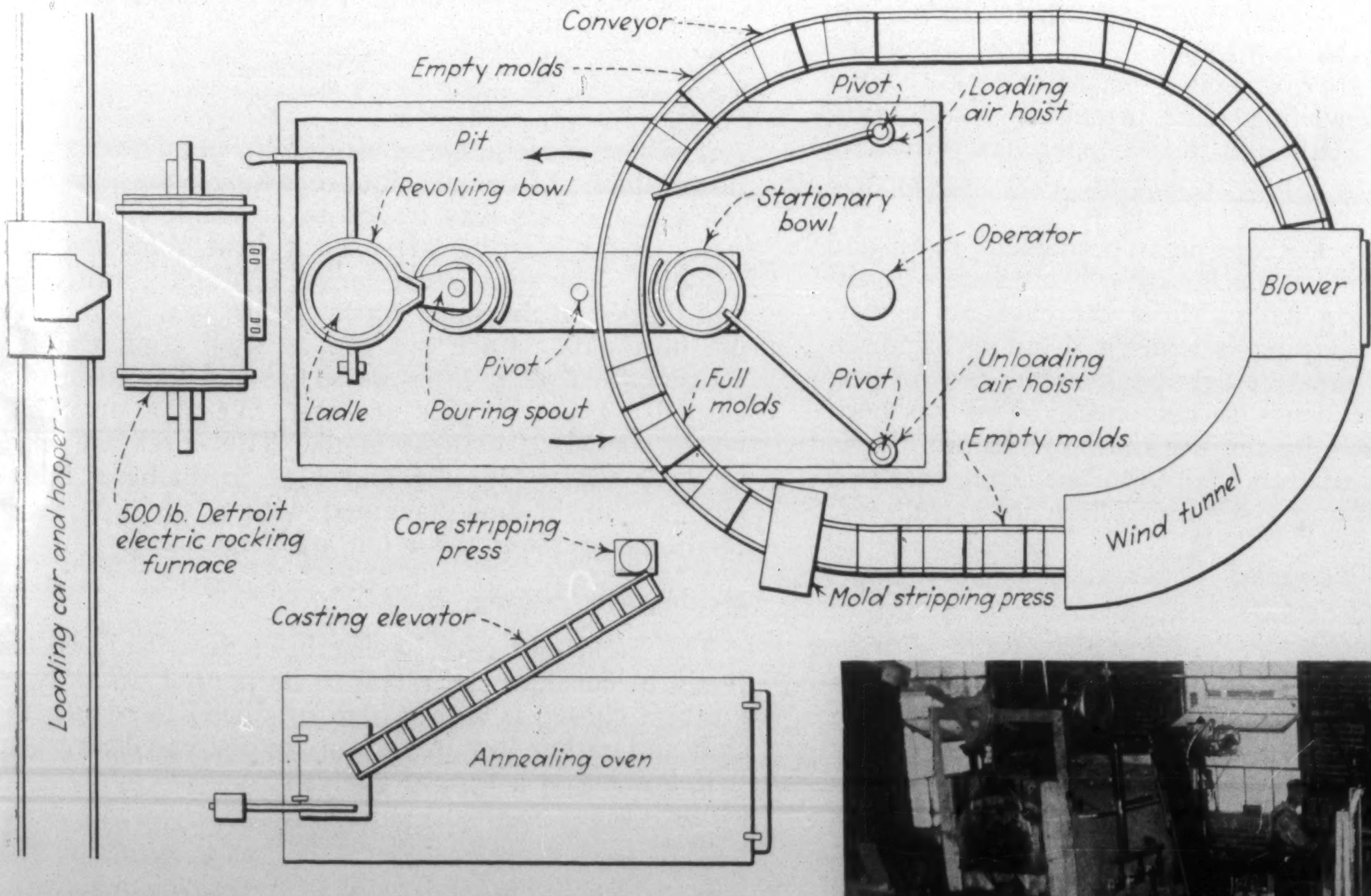
To overcome these difficulties, the D. & M. Machine Works, of Torrance, California, which specializes in pistons and rods for slush pumps, decided to try centrifugal casting, since piston cores are obviously suitable objects for such a casting process. The completed piston and rod are shown in Fig. 1. Centrifugal casting involves the development of the centrifugal device itself, of suitable molds and their cores, and the provision of a suitable cast iron mixture of precisely controlled composition and temperature for the casting itself. Each of these features required considerable experimentation.

The centrifugal device is set in a pit and consists of two bowls mounted on opposite ends of a pivoted frame.

Over one end of the pit is a platform supporting the ladle and pouring spout; in the other end a man is stationed to change molds with the aid of two air hoists. One hoist lowers an empty mold into the bowl. This bowl is then placed in pouring position by revolving the pivoted frame through an 180° arc. This places a filled mold in front of the operator. This mold is taken from the bowl with the second air hoist, and an empty mold is again lowered into the bowl with the first hoist. This change is made while the spinning mold on the opposite end of the frame is being poured. As soon as this mold is filled, the frame is again indexed through an 180° arc and the process repeated. The bowl with its mold is brought up to 600 R.P.M. before starting to pour.

New molds are brought into position to be handled by the hoist and filled molds taken away by small cars running on an oval track which crosses the center of the pit.

The general layout is shown in the sketch, Fig. 2


Conveyor
Empty molds
Pit
Pivot
Loading air hoist
Revolving bowl
Stationary bowl
Operator
Blower
Ladle
Pivot
Pouring spout
Full molds
Pivot
Unloading air hoist
Empty molds
Loading car and hopper
500 lb. Detroit electric rocking furnace
Core stripping press
Wind tunnel
Mold stripping press
Casting elevator
Annealing oven

Figs. 2 and 3 show the general layout of the foundry.

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* Foundry Superintendent, D. & M. Machine Works, Torrance, Cal.

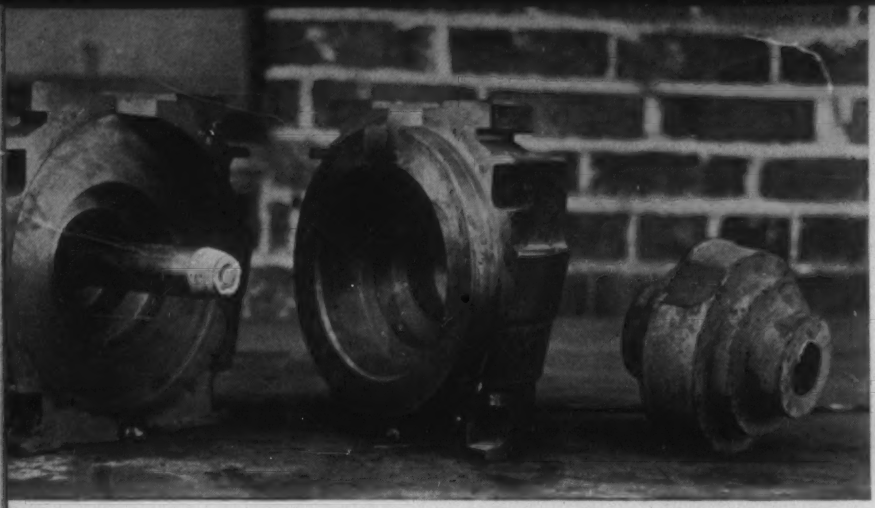

Fig. 4. Halves of the mold, the core pin and a casting.

and the photograph, Fig. 3. Using the two bowls, changing the molds in one while the mold in the other is being poured, 12 to 15 castings can be poured in 4 to 5 minutes. The filled molds are allowed to stand from 3 to 5 minutes, to allow the metal to set, before being sent to the stripping machine where the mold is pulled apart and the casting removed. The total time, from the pouring of the first casting until the last casting is in the annealing oven, will average about 15 minutes.

Molds

The molds are cast in two halves, a male and a female, and then machined to the size casting desired. The halves of the mold, the core pin, and a casting, are shown in Fig. 4. The outside of the molds is finished with a taper which corresponds to a taper in the bowls. This wedges the halves together and holds the mold in the bowl while spinning. Many different kinds of material have been used in making these molds, but to date gray iron has proved the most satisfactory.

Excellent results have been secured from steel molds, but due to their tendency to warp and burn in, the upkeep cost is high. However, they will not fire check as readily as iron molds.

Experiments are now being carried out with copper molds. At this writing some promising results have been obtained. Although pure copper has proved to be too soft, it is expected that an alloy copper will correct this trouble.

All iron molds are cast in a permanent mold and annealed to facilitate machining. Their ease of casting and machining makes them the cheapest to use. Freedom from warping is another deciding factor in their use. The greatest drawback in the use of iron molds is their tendency to fire check. This has been partially overcome by the use of molybdenum.

Various types of iron have been tried, but only two have given satisfactory results. These are as follows:

No. 1		No. 2	
Total Carbon	3.50%	Total Carbon	3.20%
Silicon	3.90	Silicon	2.50
Manganese	.80	Nickel	4.00
		Molybdenum	0.50

One type is made of straight pig iron with silicon raised 1%. The other type is made of piston iron with the addition of nickel and molybdenum. New types of iron are continuously being tried.

New molds are started on the smaller sizes, and as they fire check they are bored out to the next size larger. Casting sizes run from 6 to 8 inch and vary in weight from 18 to 40 lbs. Mold life varies from 400 to 600 castings, depending on type and size of castings made.

Before starting the day's run, each mold is cleaned with a wire brush and heated to approximately 500° F. The face of the mold is then sprayed with a wash, consisting of a high grade refractory cement, diluted 1 to 10 with water, to which is added a small amount of mullite flour and plumbago. The molds are sprayed three or four times during the day. In addition to the wash, the molds and core pins are smoked with an acetylene flame before each pour. This promotes easy stripping of both the casting and pin.

All castings under 6 inches in diameter are cast in stationary, water cooled, permanent molds. The molds are made in halves and equipped with ejector pins. Air pressure holds the two halves together while pouring. After a few minutes cooling the molds are separated by hydraulic pressure and the ejector pins eject the casting. Castings are then given the same heat treatment as the larger sizes.

Cores

During the pouring and spinning of the casting, the metal falls directly on the core until the mold is nearly filled. This made the core proposition extremely difficult.

Originally sand cores were used, but invariably they would wash and burn in. To eliminate this it was decided to use metal cores. Steel was tried for this purpose, but proved a failure; the pins either burned in or, due to the higher expansion rate, cracked the hub of the castings. Iron core pins eliminated cracking but not the burning in. A high chromium iron gave fair results, but machining costs were prohibitive. Finally, a high nickel iron was developed that solved the problem. This austenitic iron is of low thermal conductivity and hence absorbs heat slowly and by the time the pin has reached the temperature of the iron, the metal has already set. Very few pins have burned in since this metal has been in use, and if the pins are not stripped too hot, leave a very smooth hole.

The analysis of the core pins now in use is as follows:

Total Carbon	3.20%	Chromium	2.50
Silicon	1.50	Manganese	.80
Nickel	32.00 to 36.00		

The use of metal core pins developed another source of trouble. After one or two castings, the pins gave off a gas. This was traced to an oxide film on the pin. Sand blasting after each heat remedied that trouble. The pins are cleaned while still fairly hot and dipped in the same wash that is used on the face of the molds. Each pin can be used approximately 20 times before it loses its shape and has to be discarded. The core pins are cast, five at a time, in a water cooled permanent mold. The cores are made in three sizes: 1⅛, 1⅜ and 1⅞″ in diameter allowing ⅛″ finish, and machined with a slight taper to facilitate pressing them out of the casting.

Melting and Pouring

The mold and core having been described, we are ready to consider the metal to be poured. The composition chosen is rather high in silicon to reduce the chill and rather low in carbon for increased strength.

Following is a typical analysis:

Total Carbon	3.10	Phosphorus	.242
Silicon	2.30	Sulphur	.066
Manganese	.70		

Regardless of the type scrap used in the charges or the time of day when the tests are taken, there is very little deviation from the above analysis.

Average properties on standard A.S.T.M. arbitration test bars are as follows:

Deflection on 18″ centers	.24 inches
Load	2315 lbs./in.^{2}
Tensile strength	35,400 lbs./in.^{2}

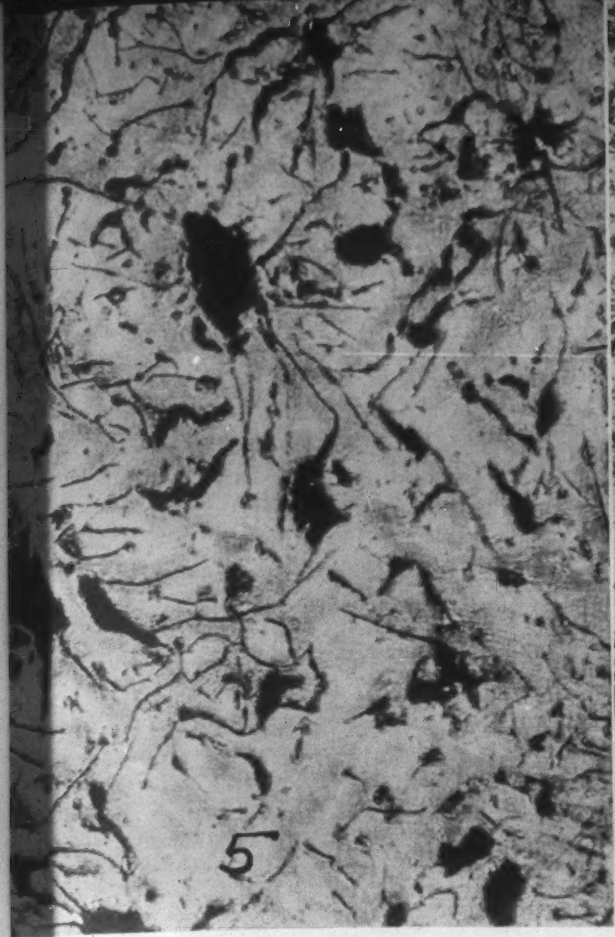

Fig. 5. Ordinary Cupola Iron. Note the large grains of pure graphite which tends to weaken the iron. 100X.

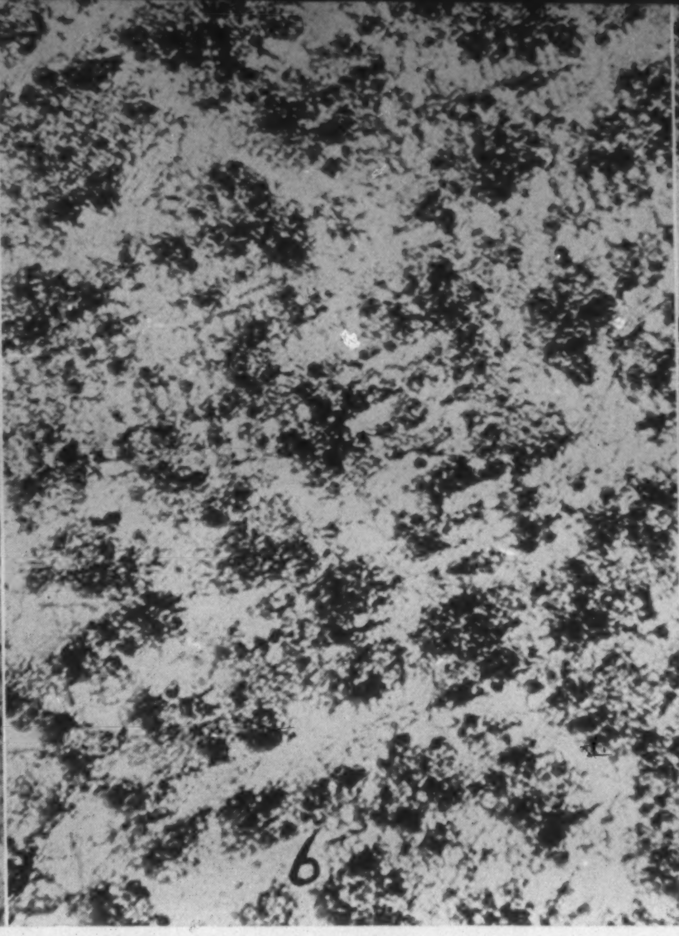

Fig. 6. Section out of Outer Rim of Piston. Note how the graphite flakes have been completely broken up. 100X.

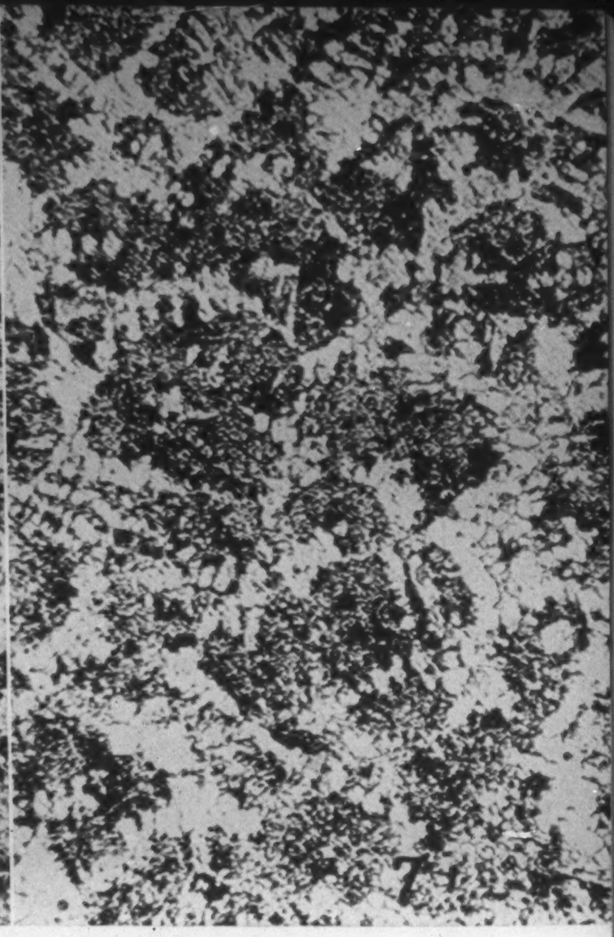

Fig. 7. Section of D & M Electric Iron out of Hub of Piston. 100X.

Shrinkage is controlled to a large extent by the centrifugal action of the metal when pouring. This action promotes high density, small grain structure and exceptionally sound castings.

Although no physical comparisons have been made between castings made in sand and castings now produced, field tests have shown the superiority of electric iron. In deep well drilling where the old type core failed, pistons with electric iron cores have been successful.

The charge used normally contains considerable borings. Disposal of borings, which amount to approximately 800 lbs. daily, formerly caused a good deal of trouble as there is no market for borings on the Pacific Coast. With the installation of the electric furnace, all the borings, rod ends, steel turnings and other scrap is used. A typical charge is as follows:

Steel	20%	Foreign	25%
Borings	30%	Pig	25%

Many heats have been made using all borings or all scrap. No exact data have been secured on melting loss on borings, but it will not exceed 5%. Metal remelt due to the small pouring gates which are sawed off on a power saw, pigged metal and spills will average about 7%. Defective casting loss in the foundry will average about 2%.

Although it is not necessary to use pig, it is used chiefly to add weight and raise silicon content. In adding a 375 lbs. charge to the 500 lbs. Detroit Electric furnace, it is necessary to keep the charge as compact as possible.

Carbon and silicon additions vary, depending on the type of scrap used in making up the charges. The necessary carbon and silicon are placed in the center of the charge, to be carried under the surface of the bath in charging.

The metal is tapped at 2950° F. and allowed to cool to 2700° before starting to pour.

The ability of the electric furnace to super-heat the iron is an important factor in producing an iron with a uniform structure. The high temperatures involved throw all graphite nuclei into solution. This results in an iron in which the graphite is finely divided and evenly distributed.

The metal is poured fast at the start, and as the mold fills, the metal stream is tapered off. When filled, the mold is allowed to spin a few seconds, then a bit more metal added. Carbon is another important factor in controlling the shrinkage.

Details of Furnace Practice

The furnace is lined with mullite brick, a neutral aluminum silicate material with a low coefficient of expansion and contraction. Formerly a plastic lining rammed in around a form was used. This type of lining did not give satisfactory service.

A brick lining was tried, and found to be easier and cheaper to install, and also gave better results in resisting the wash of the metal. With care, the lining will last a year. A water cooled door frame with a larger opening has replaced the original frame and door. Excellent results are being had from this change. Where formerly the lining around the door and spout had to be repaired once a week or more, once a month is now sufficient.

All repair work, furnace patching and cleaning up is done during the night. A 500 lb. charge laid out by the day crew is put in and the furnace started at a specific time, usually 6:30 A. M. At 8:00 A. M. when the day crew come in, another 300 lb. charge is added, bringing the total to 800 lbs. While this is melting, molds are being heated up and sprayed, ladle and spout patched preparatory to the day's run. At 9:00 o'clock the first heat of 375 lbs. is tapped. The furnace is immediately rocked back and a like charge added. This process is carried on throughout the day, the first heats taking about 45 minutes to melt, and tapering to 35 in the afternoon. To empty the furnace two rounds are poured in rapid succession. Charging is done with a chute. Care has to be exercised in charging, otherwise a broken electrode will result. To overcome this as much as possible, scrap broken into small pieces is used.

The slag is raked off four or five times during the day and a light carbon layer carried on the bath. This accelerates melting and maintains a reducing atmosphere in the furnace. Occasionally some trouble is experienced with an over-reduced iron, an iron extremely hot but lacking fluidity. This is quickly overcome by admitting air into the furnace, or adding a little iron ore.

Carbon pick-up is controlled by keeping the silicon content of the bath constant and limiting the length of time the metal is carried at the pouring temperature. In making special heats, crushed carbon is added with the charge. After the bath is hot the heat input is cut down and the furnace allowed to rock until carbon has disappeared. The carbon pick-up will be about 95%.

Heat Treatment

After pressing the core pins out of the hot castings, the castings are placed on a conveyor and elevated into the annealing oven. Here they are held 30 to 40 minutes, depending on the interval between heats, at 1750° F. As they enter the oven while still a bright cherry red, or approximately 1600° F., they quickly come up to temperature.

The chilled portion is about 1/8" thick and at this high temperature the free cementite is rapidly decomposed. To prevent oxidation the furnace is kept as air-tight as possible and the burners adjusted to give an extremely rich flame.

The cooling oven consists of a long chamber with a movable bottom. A temperature of 1000° F. is maintained in the receiving end. The bottom is moved forward as each batch is dropped, gradually moving the castings into a cooler zone.

This heat-treatment, although not conducive to maximum strength, produces a close grained iron possessing excellent machinability. Brinell hardness numbers range from 150-160 in the heaviest part of the castings to 170-180 on the outer edges.

The castings are all machined on automatic lathes. Cutting speeds range from 60 ft./min., with high speed tools, to 90 ft./min. with tungsten carbide tools. Excellent results are being secured from tools, due in part to freedom from burned in sand at the surface.

Occasionally, to meet special requirements, the heat treatment is varied to produce stronger castings. This is accomplished by either oil or air quenching from 1750° F. and then drawing. Castings given this heat-treatment cannot be machined on the automatics unless cutting speed and feeds are greatly reduced.

The difference between the structure of the former cupola product Fig. 5 and of the present product, Figs. 6 and 7, is as striking as the difference in performance of the two products as piston cores.

Summary

The electric furnace applied to this centrifugal casting problem has enabled the D. & M. Machine Works to produce a core for their pistons, capable of withstanding the heavy loads involved in modern pumps with no increased production costs.

Although larger furnace installations will earn a lower power rate, operate more economically and produce larger tonnage, nevertheless castings are being produced at a figure showing a material saving over the former practice of buying castings on the outside.

It allows the use of borings and turnings, formerly a waste product, thereby producing a quality casting costing less than castings formerly purchased of outside foundries, and of greater dependability and uniformity than was possible from previous sources of supply.

It also saves considerable time and money in making castings for emergency repairs throughout the plant.

Annealing of Copper Alloys

(Continued from page 6)

would be complete without some comment on the effect of annealing atmospheres. In the copper-zinc alloys, commercial procedure up to recently, has been to anneal in atmospheres which were more or less oxidizing, such as would normally result from the combustion of fuel in a furnace. Many of the difficulties encountered in processing these alloys may be charged to the chemical action taking place in these atmospheres and the pickling necessary to remove the oxides formed. In the nickel and tin alloys, the oxidizing atmosphere produced oxides very difficult to remove. For this reason it has been common practice in annealing the alloys of high nickel content to protect them from oxidization by pack annealing in such a way as to exclude the oxygen. Recently a great deal of work has been done to provide equipment for annealing these alloys in atmospheres which will protect the surface from oxidization. While the methods used to date are largely in the experimental stage, many installations for so-called "bright annealing" are in service and we believe that ultimately all copper alloys will be annealed in this way.

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Ductile Tungsten

Samuel L. Hoyt *

No. 8 in a series of Case Histories in Metallurgical Research

IF ANY EXECUTIVE thinks that a research man can produce a new and wonderful result by the mere waving of a wand and the expenditure of thirty cents, this case history should disabuse him of the idea. To our mind, perhaps the most important points in the course of the research were first, the early work, not in itself very fruitful, of Just and Hanamann who proved experimentally that if a sufficiently tough tungsten filament could be produced so that it would stand shipment and use, it would reduce the cost of lighting, thus setting the problem to be solved, and the pertinacity, so characteristic of Dr. Whitney, with which the G. E. Laboratory kept at the job, being willing to keep on spending money because the goal was worth it.

We will remember the early filaments of 1907 in a few lamps we had in the Cornell laboratories, how gingerly we screwed them into the sockets lest they break, and what a contrast they were to the feeble carbon lamps at the boarding house. (In fact, the landlady couldn't afford to use enough carbon lamps to make it possible to study, so she provided an oil "student lamp.") It's a far cry from those fragile lamps to those in the headlights of our cars today.

While the case of tungsten was exceptional in that, as Dr. Hoyt says, it turned the metallurgy of that day topsy-turvy and nothing behaved according to Hoyle, yet in most research problems there crop up finicky little details in which the particular thing being studied has individualities, usually stubborn ones, that have to be lived with and understood before they can be surmounted or turned to use. You can't read about these idiosyncrasies in books for it will be years before the books describing them will be written. One has to learn the peculiarities by observation, much as the old workman knows his material and its susceptibility to fine-haired changes in conditions, even though he neither appraises them nor phrases them in technical terms as the scientist does.

We are fortunate in having Dr. Hoyt, who was for many years a part of the G. E. Laboratory organization, record a "case history" of such an important piece of research, and one so characteristic of research in general.—

H. W. GILLETT

THE STORY OF DUCTILE TUNGSTEN has been written in our patent literature and has been argued in our courts of law; it is well known to the incandescent lamp industry and has been the subject of private discussions both here and abroad; yet the work of Dr. W. D. Coolidge on tungsten has never been set down for metallurgists. His patent has expired, litigation on it has ceased, and his contribution is public property through the workings of our patent law. Both product and process are daily used by the lamp industry the world over, while his drawn tungsten wire also makes the windings for high temperature furnaces, the durable phonograph needles, and the important filaments in vacuum tubes and X-ray tubes. His swaged tungsten in more massive form is used as the target in his own X-ray tube and as the contact points in the ignition systems of our automobiles. His work started "powder metallurgy" in a practical way and this art has also been utilized for the important cemented carbide tools, the oilless bearings and the copper-tungsten electrode for spot welding. We might evaluate the economic worth of these products to show the significance of Coolidge's work but this need not be done with the accomplishments themselves providing a secure and lasting testimonial to the inventive genius of their creator. It seems fitting that the story of this outstanding achievement of metallurgy, and one of its most beneficent gifts to mankind, be recorded here as a permanent appreciation.

What a contrast between the tiny grain of wheat lamp for surgical use and the giant 50,000-watt—the largest incandescent lamp in the wolrd. (Courtesy Incandescent Lamp Dept., General Electric Co.)

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* Director of Metallurgical Research, A. O. Smith Corporation, Milwaukee, Wisconsin.

At the turn of the century considerable activity commenced in many countries on the production of a metal filament for the incandescent lamp as an improvement on the carbon filament of Edison. The earliest of these was the osmium filament of Dr. Carl Auer von Welsbach, of Welsbach mantle fame. Osmium metal powder was prepared as a paste, squirted into thread form, sintered, and mounted in the lamp. The metal was expensive and scarce and the osmium lamp could not compete with the tantalum lamp which was developed a little later by Dr. Werner von Bolton of Siemens and Halske, Berlin. Tantalum was a great improvement over osmium in that it could be drawn into wire. This was really an excellent lamp, but it was in turn superseded by the superior tungsten lamp. Work on tantalum directed attention to purity of the metal as having a direct bearing on its ductility. The earlier forms of tantalum were brittle but von Bolton found the metal to be ductile enough when it was properly purified. In the von Bolton patent, the thought was expressed that other refractory and brittle metals, such as tungsten, could likewise be drawn into wire if purified sufficiently, and on this basis he attempted to claim tungsten and other metals for lamp filaments. This comment was not helpful in producing tungsten wire but it was used later to support an argument to the effect that Coolidge could not be the inventor of drawn tungsten, for the initial step—the conception, had previously been taken by another. The third and last of the metal filaments was the tungsten filament to which we now turn for a more detailed discussion.

The early history of tungsten may be secured from the literature and need not be considered here at length. For over a century following its discovery as an element in 1781 many references appear which indicate that it is hard, brittle and highly refractory. We may assume from this that many scientists attempted to produce the metal in the usual cast and wrought forms but found unanimously that it was not amenable to the processes then known. Some of these references state that tungsten is extremely hard. We now know that this is not true so that it is likely that the experimenter had tungsten carbide or a mixture of the carbide and the metal. That is really immaterial for had the tungsten been pure, the report on malleability would have been the same. Prior to Coolidge's time the only reference which suggests malleability is one of Moissan to the effect that he hammered a regulus of tungsten which he had produced in his electric furnace by carbon reduction of the oxide. While this experience was capable of showing that the pure metal does have some malleability at a high temperature, nobody utilized the finding in a useful way. Presumably Moissan merely closed up the pores of a porous mass of metal and the experiment remained with significance to the art.

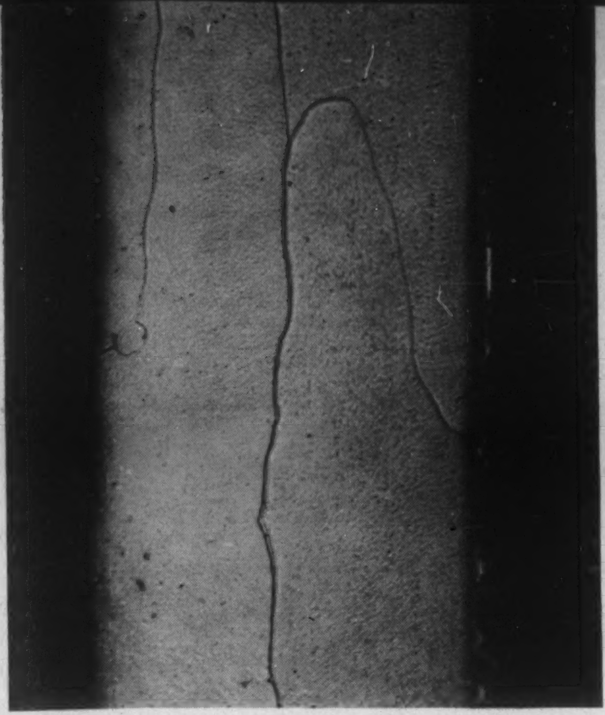
The first successful use of tungsten in the metal filament art was that of Alexander Just and Franz Hanamann who produced a tungsten filament when working in the chemistry department of the Royal School of Technology at Vienna. They took advantage of the high melting point and low vapor pressure of tungsten by operating the filament at a much higher temperature than was possible with other filaments. The filaments were made by mixing fine tungsten powder with an organic binder, squirting the paste through a diamond die, baking and heating the filament in hydrogen to remove the binder, and sintering the powder into a coherent body. They sold their American patent rights to the General Electric Company and in 1907 lamps with the new filament were sold in this country. Many will still recall the beauty of those new lamps (not "bulbs"). This closed that chapter of their career and when I knew Dr. Hanamann he was living comfortably in Germany on the proceeds of the sale and continuing his education at the Charlottenburg Technical School with Professor H. Hanemann.

Several years prior to the publication of the Just and Hanamann work, Dr. Whitney, the virile director of the recently established Laboratory at Schenectady, had initiated an extensive research program on a number of refractory metals, including tungsten, in the hope of finding something better than carbon for an incandescent lamp filament. This introduced one of the most fruitful eras of industrial research in this country. The development of the drawn tungsten filament by Dr. Coolidge became the focal point of this work, and it is to this phase of tungsten activities that we now turn.

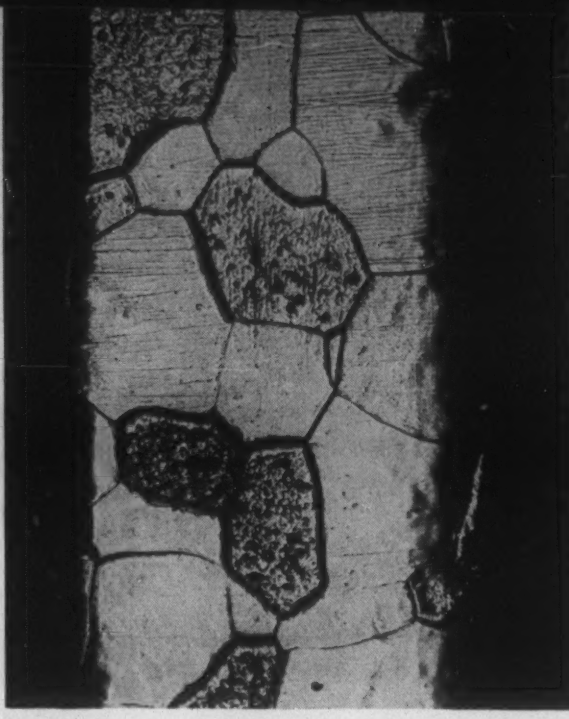
It was obvious that a great improvement might be effected if tungsten could be drawn into wire form to secure filaments of greater uniformity and strength, and to improve many phases of lamp manufacture. Coolidge had begun his tungsten work late in 1905. His earliest experiments consisted in pressing tiny rods of tungsten powder, heating them individually as anodes in a mercury arc discharge and then, subsequently, hot-hammering the melted globules so produced on the end of each rod as well as the unmelted, sintered material adjacent to the melted ends. He had found that both the melted and the well sintered portions were brittle cold, but could be flattened out by hammering at bright red heat. This gave positive evidence of malleability.

During the course of this work he developed an amalgam process for making squirted filaments, using as a binder for the tungsten powder an amalgam of cadmium and bismuth. The development of this process occupied a good deal of his time, but, while engaged on it, he visualized the possibilities of tungsten wire and from time to time experimented on tungsten with that idea in mind. The squirted and sintered filaments served as material for further experiments. He noted that squirted filaments could be bent hot around the support wires and found that a loop thus made could be flattened hot between two heated steel plates. He found later that a filament could be coiled into a spiral by being wound around a heated mandrel. Thus Coolidge discovered what others had missed, that tungsten is malleable when hot.

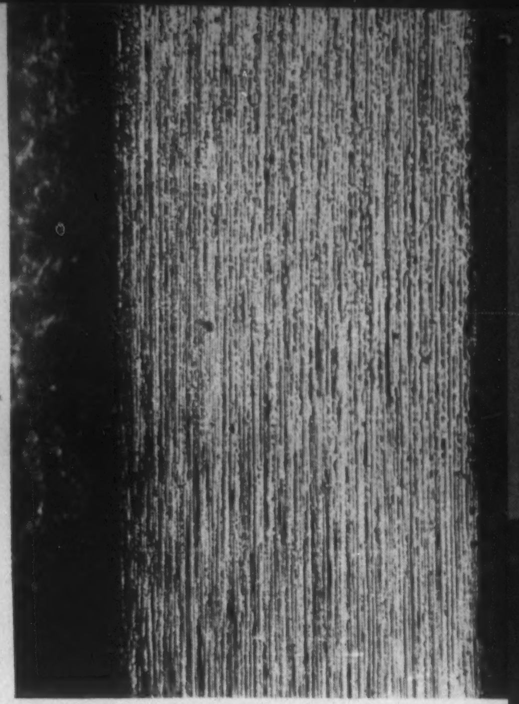
With the teachings of tantalum in front of him, Coolidge had, at the very beginning of his work, tried to make tungsten ductile (in the usual sense) by making tungsten purer. His experiments convinced him that the brittleness of tungsten was not due to the presence of impurities, but was inherent in the metal. Later work by others along the same lines likewise gave negative results. In fact, long after the art of handling tungsten was well under control this line of experimentation was repeated with specially purified tungsten, but even this metal was brittle the same as ordinary tungsten and required the same manipulation. Of course, tungsten is purified during manufacture in the sense that oxygen and other injurious ingredients are eliminated to avoid harmful characteristics, filament defects, etc., but even pushing purification to the extreme does not make tungsten workable like other metals.



Fibrous structure of drawn tungsten wire X 250.



Structure of thoriated filament after burning in lamp X 250.



Structure of "218" filament after burning in lamp X 250.

(Courtesy Incandescent Lamp Dept., General Electric Co.)

To close the first period in the development of wrought or drawn tungsten, Coolidge found by more careful observations that if tungsten in massive form were deformed once, then reheated and deformed again, it could be materially altered in shape without cracking. This work suggested, what subsequent development proved definitely, that a small amount of deformation at one temperature made it possible to continue deformation at a lower temperature or at a temperature at which unworked tungsten was brittle. This not only showed the significance of hot working but opened up a vista of what might be accomplished by artificial manipulation. As a practical method of handling tungsten Coolidge visualized the rolling mill with heated rolls and he actually rolled out amalgam process filaments in this way. But tungsten was not to be so easily conquered as to fit into such a standard process, and even now rolling is not used in wire manufacture. As yet Coolidge had not worked on swaging but he had outlined a process of rolling the larger sizes and hot drawing through heated diamond dies to finished size. This was the status after the work of 1906 and the early part of 1907. These early experiments on the characteristics of tungsten were very carefully performed and critically analyzed, and we shall see later how he utilized his findings of this period to develop the commercial process of swaging and drawing.

At this time Dr. Whitney was interested in various other refractory metals, one of which was molybdenum. This metal is in the same family of elements as tungsten and the two were known to have some characteristics in common. When Dr. Colin G. Fink started to work at the Research Laboratory in May, 1907, he was assigned to work on molybdenum with the idea of paralleling the work on tungsten. Molybdenum also had another interest at that time. It was thought that experience with molybdenum might shed some light on the tungsten problem. Actually it turned out just the opposite; methods which were successful when used with molybdenum were unsuccessful with tungsten but the equipment and processes which were ultimately developed for tungsten provided the most suitable means for making molybdenum wire and today the two metals are handled very much alike.

Any interest in molybdenum as a lamp filament was short lived for life tests showed that molybdenum had too high a vapor pressure to compete with tungsten. The cheaper molybdenum has since found relatively few applications.

The second period, as assumed here, covered the hot drawing of tungsten through diamond dies. The distinction of having been the first to do this fell to Fink in October, 1908, though historically this period dates back into the early part of 1907. At that time Coolidge had reached his conclusions on a procedure for drawing tungsten hot and had received approval of Dr. Whitney to take up the work as soon as possible. In the meantime he was occupied with his amalgam process and its introduction into the lamp factories and work on drawing tungsten was not pushed until 1908.

A number of things happened at this time which are of historical interest and which subsequently raised a question as to Coolidge's right to the patent. During 1908 work was well under way on molybdenum filaments which were prepared by the amalgam process and life tested in the usual way. At this time, or during the summer of 1908, Coolidge went abroad to visit European factories and while in Berlin he encountered squirted molybdenum filaments which were ductilized by annealing or sintering in a bottle of hydrogen. Of what significance was this to Coolidge? At that time knowledge of the metallurgy of tungsten and molybdenum was extremely limited and this molybdenum filament, which had been made ductile by an annealing treatment, suggested the possibility (to Coolidge) that tungsten would be made ductile by the same process. His thoughts on this point were communicated to Dr. Whitney by cable and letter. This was the first time that a ductile molybdenum filament had knowingly been made and Dr. Whitney responded to this stimulus by having the German work repeated and confirmed. Among other things Fink, who took part in this work, found that one of the molybdenum filaments he had made the year previous (by the amalgam process) could be drawn cold through a diamond die. In other words he had already made a molybdenum filament which was ductile cold.

Much has been made of this happening in an attempt to show that work on molybdenum taught the art of drawing tungsten, though it should be pointed out parenthetically that such an assertion was never made by a metallurgist. If true, it was argued, such a showing would invalidate the Coolidge patent; but one fact alone is sufficient to lay such an erroneous proposition. While squirted molybdenum was made ductile cold by a bottle annealing treatment, squirted tungsten remained brittle after such a treatment.

This work on molybdenum is more confusing than

One of the final inspections in the complex technique in manufacturing high-quality lamps. This is the "Flash" test to make certain the lamps actually light. (Courtesy Incandescent Lamp Dept., General Electric Co.)

helpful in tracing the development of tungsten and even though it played an important part in the laboratory work at Schenectady at that time (summer of 1908) no attempt will be made here to describe it in detail.

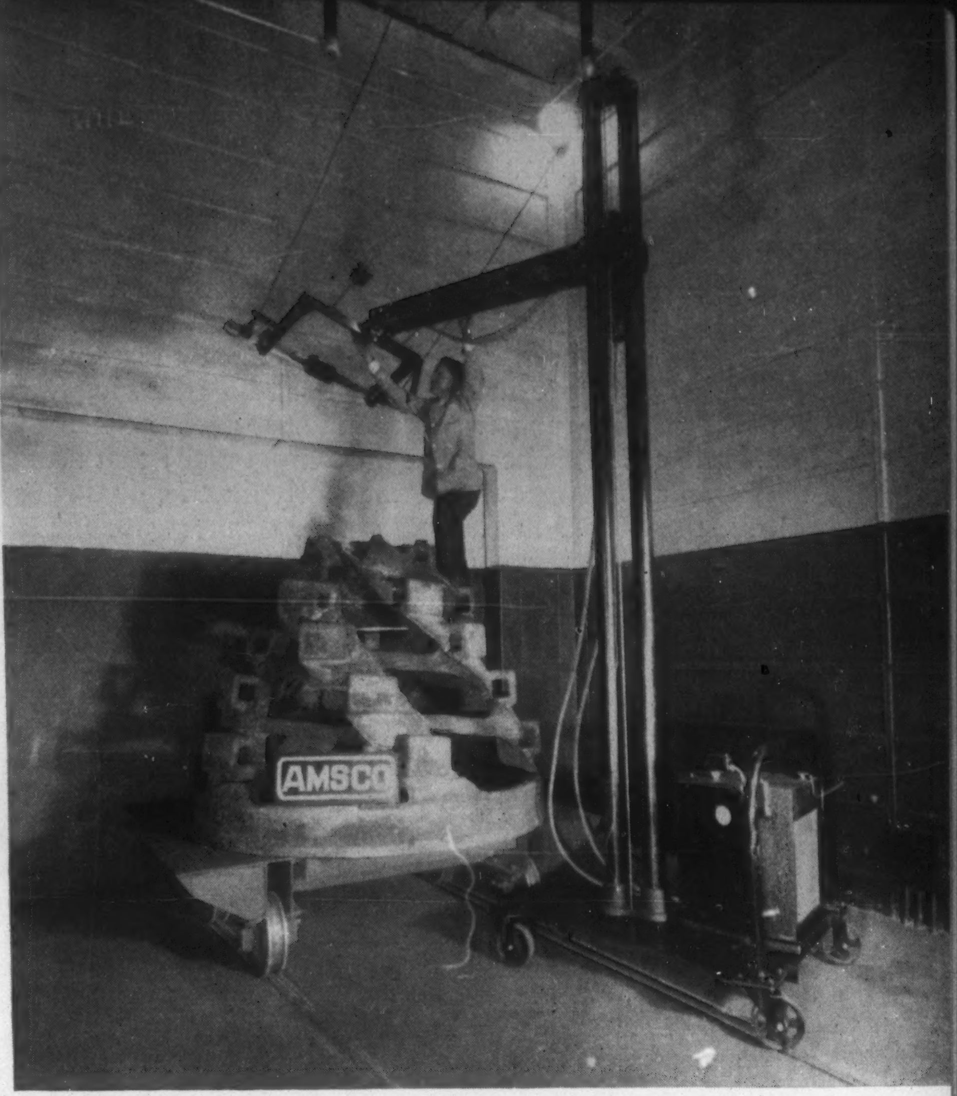
To continue with the period of hot drawing tungsten, Coolidge returned to Schenectady in the early fall and took over the direction of the laboratory while Dr. Whitney was in the hospital. He found conflicting views on drawing tungsten which had somehow to be ironed out. One idea was that if tungsten were to be drawn, it must be put into an initially ductile condition, as molybdenum had been. This seems simple enough and entirely reasonable, except that it doesn't work. To proceed with this idea one would anneal the starting material and then proceed to draw it, just as one would do with copper, etc. Coolidge's idea was that it was futile to attempt to put tungsten into an initially ductile condition, but that it might possibly be drawn hot, in which condition it would at least be plastic. To test this out it would be necessary to try the experiment. The work on molybdenum showed that a squirted filament had enough strength to be drawn and hence it was not unreasonable to attempt to draw tungsten prepared the same way.

Inasmuch as these conflicting ideas involved different procedures, Coolidge insisted that work on hot drawing be given preference. On account of his administrative work, Coolidge did not do this personally, but turned the assignment over to Dr. Fink. The first length of tungsten was drawn in October, 1908, from starting material made by the amalgam process. Work of this kind was continued by Fink during the following months to show that tungsten could actually be drawn into wire, and to close the second period. This was the most spectacular part of the whole development. Tungsten, the metal pronounced brittle by all, was actually drawn into wire by the simple expedient of performing the operation at an elevated temperature. Ordinarily hot drawing is out of the question because raising the temperature involves too great a sacrifice of strength, but Coolidge knew that it was either that or nothing. Fink and his assistants continued this work on drawing tungsten hot and with careful and skillful technique they showed that one piece after another could be drawn, first through one die and then through additional dies, finally to secure a wire of small diameter which had been considerably reduced. Upon testing the wire for ductility when cold, Fink made the startling and interesting discovery that the wire had become ductile cold as the result of the continued hot drawing. This was "ductile tungsten." And yet this terminology was confusing; how odd that it should become ductile only *after drawing* when, by definition, it could not have been drawn were it not ductile. Later it was shown that the hot working produced the highly artificial "fibred" condition in tungsten which, by combining great strength and ductility, puts tungsten into its most useful form. As compared to other metals tungsten was shown to be a paradox for never before had a metal been made so much stronger and simultaneously been converted from a brittle into a ductile condition by mechanical working. This paradox was intensified when it was also found that an annealing treatment which eliminated the effects of working made tungsten brittle again. We shall later revert to a more detailed consideration of this paradoxical nature of tungsten.

Interesting and spectacular as this second period was, much remained to be done before the process was developed to a practical commercial stage. The filaments used for starting material were only 10 to 25 mils in diameter and the finished wire came out in short lengths and much breakage occurred. It became necessary to learn how to produce tungsten in larger sizes, or in "ingot" form, and a method of working the ingots had also to be developed. Both of these steps were taken only after the most laborious and painstaking experimentation and after discouragements which threatened to wreck the whole investigation. Thus we come to the third period in the development of ductile tungsten with Coolidge again in active charge.

The first attempt to make larger starting bodies consisted of using the amalgam process to make rods up to ¼ in. in diameter. All such attempts failed to give rods free from checks when the amalgam or binder was driven off. The next step was to press up ¼ in. square bars or "ingots" in a knock-down mold on a side ram press and this, for the first time, introduced the real intricacies of powder metallurgy. While most any tungsten powder can be extruded when mixed with a binder, the straight powder must be properly prepared before sound ingots can be pressed. This involved a painstaking study of the whole procedure of making tungstic acid, firing the oxide, reducing the oxide in hydrogen to give the proper particle size and particle size distribution, while retaining the requisite purity. Even the design of the mold and method of filling the mold had to be carefully considered. Finally, it became possible to make ingots which came out without pressing defects.

Methods had then to be devised for handling the loosely coherent metal bar as it came from the mold,



X-ray installation for the inspection of castings at the American Manganese Steel Company. Diagnostic radiographs are routinely made through five inches of cast steel. (Courtesy General Electric X-ray Corp.)

for sintering it in a hydrogen furnace to make it strong enough to handle, and for heating it in a hydrogen "treating bottle" to just below the melting point to complete the sintering action.

The procedure for securing satisfactory ingots was finally worked out and various processes for mechanical treatment were taken up. Rolling and forging were both tried and eliminated. Metal which could be drawn hot when in the squirted form could not be worked by forging or rolling, though the ingot showed no defects. Even the most skillful and experienced workmen could do nothing with tungsten bars at the size of ¼ in. Heating the rolls resulted in a little progress, but not enough. Coolidge finally decided to try swaging to take advantage of the circular shape of the swaging dies. Little success was had at the start, the reason being that the swaging art as then practiced for cold forming ductile metals was inadequate to handle the new material hot; both the equipment and the methods of swaging had to be revised before the process was a success. Principally it was necessary to go to short bearing dies to limit the blow to only a small portion of the length of the rod, and the speed of feeding the rod through the dies had to be adjusted so that the portion which had received a blow would pass on and not receive a second blow. After these steps had been worked out Coolidge was able to swage tungsten ingots according to the scheme he had set up though he had still to work out a schedule of reductions and temperatures which would properly fibre the rod but which would not overwork the metal and cause it to split. The temperature at the start of swaging was in the range of 1500° to 1600° C. This was hot work in the sense that it was done at an elevated temperature, though in the sense that it was done below the annealing temperature for tungsten it was cold work. At any rate, the temperature was correct for producing a fibrous structure. This temperature was lowered as swaging progressed.

Just as it seemed as if the art of swaging tungsten was well in hand it was found to be impossible to swage below 125 mils. Attempts to begin hot drawing at that size were also unsuccessful due to the lack of suitable dies in the large sizes. This impasse was overcome by installing a small swaging machine with a gas furnace in front and feed rolls at the rear. These feed rolls pulled the rod through the heating furnace, into the dies and out. In this way the rods were reduced to 30 mils, after which they were drawn through diamond dies using technique similar to that which had already been developed.

This completed the work of the third period. It was the most difficult and trying of the three, and also the most remunerative for the success which attended Coolidge's efforts here, gave him a process for the commercial production of tungsten wire.

Tungsten wire was adopted for lamp manufacture in the fall of 1910 with the transfer of the process to the lamp factories. There still remained much to be done to lower the manufacturing costs, increase the die life by better lubrication, secure uniformity of the product, improve its quality, develop special wires for specific purposes, etc., and wire development has continued as an active investigation both at Schenectady and in the factories.

The product which results from this process is unique metallurgically in a number of ways. It is the strongest wire known with a tensile strength of about 600,000 lbs./in.^{2} as compared to the strength of the strongest steel wire of 400,000 lbs./in.^{2} It has the highest modulus of elasticity known of 60,000,000 lbs./in.^{2}, or twice that of steel, and has the lowest coefficient of thermal expansion of any metal. The drawn wire has made it possible to make lamps which are cheap, rugged, efficient and uniform in rating and performance and in sizes which vary from 30 kilowatts to a small fraction of one watt.

The paradoxical nature of tungsten is nowhere brought out more clearly than in discussions of the "ductility" of the metal. One can argue that tungsten is ductile like copper or, conversely, that it is as brittle as glass, and bring support to either premise. The metallography of tungsten is not so simple that such general statements, with their broad implications, are competent to give a fair or accurate description of the metal. Of course, the Schaller single crystal filament is used to support the first statement as this fine thread can be rolled, drawn or even tied in a knot cold. On the other hand one quickly runs into difficulties upon comparing the ductility of tungsten with that of the common metals. Copper can be rolled cold to a reduction in thickness of 5,000 to 1 starting with a bar one inch square while, under the same circumstances, tungsten would break up in the first pass whether single crystal or fine grained. While tungsten in the artificial form of a single crystal thread is ductile to a surprising degree, it is obviously improper to say that the metal is ductile like the common ductile metals.

Curiously enough one can argue that the addition of the non-metallic thoria makes tungsten ductile, though the reason for this is indirect rather than direct. Jeffries and Schaller have shown independently that the addition of a large amount of thoria makes it possible to heat tungsten so that a coarse grained or single crystal structure results. Such coarse grains show the ductility of the single crystal form which has already been described. In much the same way one could argue in either of the two following ways, (1) that a tungsten filament becomes permanently brittle once it is heated in the lamp, or (2) that a tungsten filament becomes permanently ductile, or throughout the life of the lamp. In the former case the filament becomes fine grained and equiaxed and in the latter case it develops large, elongated grains. Oddly enough the former filament is thoriated, though the amount of thoria is less than that required to make tungsten coarse grained. In the latter case there is likewise a small amount of nonmetallic matter present and our best theory to account for this behavior is that the amount is just enough to alter the recrystallization characteristics of (pure) tungsten but insufficient to produce the fine equiaxed structure. (Jeffries). To complete and clarify this discussion we may say that tungsten reacts in a number of different ways, depending on its condition and treatment. The pure metal recrystallizes in wire form to produce an equiaxed structure whose grains grow fairly rapidly to cover the whole section and produce "offsetting." This first type of wire is not used for lamp filaments. With a very small amount of nonmetallic matter present the wire recrystallizes to produce a long, overlapping, granular structure which approaches the single crystal in behavior. With 1% thoria present the wire recrystallizes to produce a fine grained, equiaxed structure which prevents offsetting. The second type of wire is used for coiled filaments as its coarse structure resists sagging, while the third type is used for the straight filament in the vacuum lamp. With two or more percent of thoria the metal powder produces the single crystal or coarse grained structure already mentioned. Other types of metal could be mentioned but these will suffice for our present purposes.

The metallographist will want to remember that the tungsten crystal has a properly functioning slip mechanism but that the practical utilization of this mechanism is very limited. For example one cannot make a large single crystal, roll it cold, and finally draw it cold into a filament, even though intermediate annealings be used. It is of greater significance that one cannot do that even with a fine grained ingot though each grain be normally ductile. The slip mechanism is obstructed in the first case by a small amount of plastic deformation and in the second case by grain boundaries. The latter effect is reminiscent of gold which contains a small amount of bismuth but it has never been shown that intergranular brittleness in tungsten is due to impurities. Quite the contrary, purifying tungsten has never made tungsten ductile in the ordinary sense; those are not the related factors. If one wished to argue that there is, after all, a similarity between tungsten and the impure gold, the white skeletal residue found by Van Brunt when he dissolved tungsten in an alkali could be used in support. This residue is like the "Zwischensubstanz" of Tammann and one might hold that it makes fine grained tungsten brittle. However, he would then have to account for the brittleness of the thoriated filament directly after the first heating and throughout life. During life the grains slowly become larger and one would have to assume that by diffusion the impurities always move to the grain boundaries, but the intergranular brittleness of the freshly equiaxed filament occurs too rapidly to be explained by a diffusion process. When one recalls this paradoxical behavior of tungsten it is all the more remarkable that Coolidge was able at that early date to find the only process which is capable of producing tungsten filaments in a practical commercial way.

With the history of this development fresh in mind it seems appropriate to turn to an appraisal of Coolidge's work. The acclaim with which the new filament material was received by the lighting industry is a matter of history. It appeared that the "impossible" had been accomplished and to analyze this phase of the matter, we may inquire into what the attitude of a metallurgist of the day might be toward the product and the process by which it was made. Upon examining a piece of the drawn wire and noting its strength and ductility he would be baffled to explain how such a wire might be produced from the brittle ingot. He might account for a change in a pure metal from a ductile to a brittle condition by mechanical treatment, but the reverse would be beyond him. Upon examining the microstructure and noting its fibrous character his first impulse would be to doubt the evidence. And if he were to heat the fibred wire above its annealing temperature to make it fine grained and equiaxed, the brittleness which would develop would make his confusion more profound. The ingot and the powder with which it was made would remind him of nothing in common metallurgy while if Dr. Coolidge were to explain the steps through which the ingot would go and describe just what was happening at each operation and the relationships between operations, he would hear nothing with which he was familiar. In fact, by this time he would feel that he was listening to a sort of topsy-turvy metallurgy.

If Coolidge had melted tungsten, poured an ingot, rolled it hot, and finally drawn it cold through diamond dies, no claim for a novel metallurgical process would have been valid. Statements in the literature or the experiences of others to the effect that tungsten is brittle would not have been sufficient to show novelty. In that case Coolidge would simply have corrected an erroneous impression. Other principles of chemistry and metallurgy were also available for handling tungsten and were tried by many, including Coolidge, but, in brief, Coolidge was alone in making use of the peculiar fibering characteristics of tungsten when mechanically worked at elevated temperatures. Where others failed or stopped, Coolidge went on and developed a new principle for the working of metals; e.g. a small amount of working at one temperature (at which the metal is malleable) induces malleability at a lower temperature at which it had been brittle before being worked. This, as I see it, was Coolidge's real contribution to the theory of drawing tungsten wire. Expressed in terms of the structure it means that to produce "ductile" tungsten it *must* be worked at a temperature at which it is simultaneously malleable and capable of being fibered. If the temperature be too high no fiber will develop, and if too low the material will break up. This principle covers the initial swaging with short bearing dies and the controlled speed of feeding and the graded temperature drop through swaging and drawing. How different this is from the art of drawing or rolling other metals where, in principle, the work is done so that fiber does not develop or if it does form, it is periodically eliminated by annealing above the equiaxing temperature. Coolidge disclosed another prin-

More than 480 tests and inspections are made during the manufacture of high-quality lamps. For example, here is one to make certain that the base and filament are positioned accurately. (Courtesy Incandescent Lamp Dept., General Electric Co.)

ciple for tungsten which is that it does not stand sidewise deformations or "spread" after the fiber begins to develop. This difficulty was avoided by the use of the formed swaging dies. Up to his time nobody had ever started with a metal with a fine grained equiaxed structure which was brittle as glass when cold and by a process of mechanical treatment below the annealing temperature converted that metal into a fibered condition which was both strong and ductile. This has never been questioned, and yet serious doubt has been cast on the validity of the claims of his patent and even on his right to invention.

Before proceeding to that part of the story of ductile tungsten we shall digress briefly to consider the characteristics of tungsten in single crystal form.

Just prior to the World War a process was developed in Germany by Schaller for making filamentary threads of tungsten which were one single crystal. These Schaller single crystal filaments were not known in this country until after the war. Briefly a squirted tungsten filament was passed at a fixed rate through an electric furnace operating at about 2400° C. This caused a grain of tungsten at the hot zone to continue growing by absorbing the oncoming small grains and thus to grow into one long crystal. These crystals were of the order of a few mils in diameter and were quite soft and pliable even at room temperature. This would appear to contradict what has been said about the brittleness of tungsten and it may be taken as showing that the individual grains in a fine grained and equiaxed tungsten ingot are ductile cold, but the Schaller process did not have and could not have any bearing on Coolidge's work. First, the commercial ingots as prepared are actually fine grained (overlooking the coarse grained or "plated" ingots which must be treated the same way as the fine grained ingots). They are brittle and must be swaged and drawn according to the Coolidge process. Second, if a single crystal of tungsten be prepared large enough to serve as a starting body it too is brittle and would have to be swaged and drawn according to the Coolidge process. Ingenious as was the Schaller process for making a single crystal tungsten filament and interesting as its properties are, the Schaller process has never had any practical bearing on the manufacture of tungsten filaments and is not so used. Before Coolidge's patent issued, he knew of this pliability of tungsten in thin sections and this whole situation was subsequently cleared up by the metallographic investigations of Dr. Zay Jeffries.

We have now covered the development of the Coolidge process for drawing tungsten wire or for the manufacture of "ductile tungsten." Applications for a United States patent were filed in 1906, 1909, and two in 1910 and on December 30, 1913, U. S. Patent No. 1,082,933 was granted to Dr. W. D. Coolidge and assigned to the General Electric Company. This patent described the process very thoroughly and both process and product claims were allowed. Representative claims are No. 2, "The process which consists in agglomerating tungsten powder, sintering the body thus formed, subjecting it to repeated hot working and continuing such hot working until the body remains ductile when cold," and No. 24, "A wire formed of ductile tungsten." These claims indicate the breadth of the patent which was allowed. It is interesting that the process of claim 2 is still used to make the product of claim 24, twenty-four years later, in all countries where wrought tungsten is produced.

Leaving the technical aspects of Coolidge's work, we may pass to the intimation made above that the validity of Coolidge's patent had been questioned. Of course the process covered by the Coolidge patent was extremely valuable and many tried to avoid it by one means or another while others, in the opinion of the General Electric Company, copied the process and infringed the patent. Two suits were brought for alleged infringement which involved a thorough consideration of both product and process claims. In this litigation it was the final decree that the process claims were valid but that the product claims were invalid. At one time the process claims were held invalid because, in effect, the mechanical treatment of metals being old, Coolidge simply applied old art to a new metal. The malleability of tungsten at an elevated temperature was a "discovered" property and not patentable. The decision of the higher court reversed this finding and recognized the fibering principle that Coolidge used. The decision incorporates a part of the plaintiff's brief (General Electric Company) as follows:

> "The process which brings out the ductility of tungsten destroys ductility in other metals. The condition in which tungsten is most ductile is the condition in which other metals are least ductile; the condition in which other metals are most ductile is the condition in which tungsten is least ductile."

The process which was used to produce this new result had never been used before, it was new with Coolidge, and hence all the straight process claims were finally held to be valid.

In passing on the product claims the court was necessarily restricted to the description of the product as given in the claims. At the time the patent was drawn the only form of coherent tungsten known was the sintered, crystalline and brittle filament of Just and Hanamann. The product claims, of which No. 24 is typical, distinguished between the new and old forms of tungsten but in characterizing the new form, the emphasis was placed on ductility. The Schaller single crystals demonstrated the ductile character of a tungsten crystal in small sections, because uninfluenced by any grain boundary effect, and this circumstance caused the court to hold that ductility was a natural property of tungsten and hence not patentable subject matter. The Schaller single crystal filament was not only as much an artificial product as fibrous drawn wire, but also much later than Coolidge. When looked at from the metallurgical standpoint what Schaller did was most ingenious and he deserves much credit. His product, however, should rate as an improved squirted filament and from the utility standpoint it is not in the same class as the Coolidge product. Had Schaller been earlier than Coolidge the development would have had more claim to anticipation of certain of the broad claims in the Coolidge patent, but in no case should have affected the claim specifying working or fibering.

Claim No. 34 is interesting in this connection. It reads:

> "Wrought tungsten, a solid coherent material characterized by the presence of crystals deformed by mechanical working."

The General Electric Company argued that this was the broadest product claim, covering the more specific claims relating to wire and filaments and no mention is made in this claim of ductility. The subject of this claim is artificial or man made and relates to a manufacture so that the ductility of natural tungsten would appear not to be involved. The point was not settled for the court classed this claim as an "intermediate product" claim, or as one which would relate to the swaged X-ray target, and found it unnecessary to pass on its validity.

It has been intimated that Coolidge's right to the invention covered by his patent has been questioned. In other words the validity of the patent has been attacked because issued to the wrong person. The basis for this attack was the work done by Fink on molybdenum in the summer of 1908 and on tungsten in the fall of the same year. There can be no doubt that Fink made a splendid contribution to the drawing of both metals and in his behalf a claim to the invention of ductile tungsten was advanced and argued with extraordinary vigor. The General Electric Company defended its position in applying for the patent in Coolidge's name, rather than in Fink's name or jointly in both names, with equal vigor. Of course there was no additional question of the rights of the General Electric Company for both Fink and Coolidge were employees of the company. The General Electric Company asserted, and supported its assertion by examination of Fink, Coolidge and experts, that the so-called ductilization of molybdenum had been accomplished by an annealing treatment in hydrogen while the ductilization of tungsten was accomplished by mechanical treatment, that obviously the work on molybdenum did not teach the tungsten art. Even though Fink did his work on molybdenum while Coolidge was away in Europe it had no bearing on tungsten. Secondly, the General Electric Company argued, Fink's work on tungsten was done under Coolidge's supervision and in accordance with his instructions, and it carried out ideas which Coolidge had developed over the two years prior thereto. Further the whole art of swaging tungsten was worked out by Coolidge alone. Finally the General Electric Company argued that before filing the final amended application its legal staff had carefully and thoroughly considered the history of the development at a conference with both Coolidge and Fink and that as a result of this meeting of minds when all the details were fresh its opinion was that Coolidge was the sole inventor. In the final court decision the patent was adjudged not invalid because issued to the wrong person.

A review of the history of this development today makes it increasingly clear that of the many in this country and abroad who were working on tungsten, Coolidge was the one who had the clear conception of what was necessary to produce tungsten in wire form. His guiding thought was, simply enough, to do the things that were possible and necessary to draw tungsten. In carrying this out Coolidge recognized the inherent differences between tungsten and other metals; and from what we know there were good reasons for his success. The cold ductility of his end product was quite secondary to achieving the primary object of producing wire. Discussion on this point simply makes "confusion more confounded" and does not warrant the attention that this property has attracted except for its scientific interest. Coolidge learned how to prepare tungsten powder, how to press it into ingot form, how to sinter the ingot, how to swage the ingot into a rod, and how to draw the swaged rod. Summating this we may say that Coolidge learned how to make fibrous tungsten in wire form commercially. The secret of this was the fibering principle and he utilized it as the only means of drawing tungsten. The hot malleability of the ingot was a necessary property, and the cold ductility of the drawn wire was a useful end result, a property of the fully fibered material.

At a reorganization meeting of the **Copper & Brass Research Association,** held at its offices, 25 Broadway, New York, the mining companies withdrew and the fabricating members formulated plans for a promotional campaign for the forthcoming year. The following officers were elected: President, F. S. Chase, President, Chase Brass & Copper Company; Vice-Presidents: John A. Coe, President, American Brass Company; C. D. Dallas, President, Revere Copper & Brass Incorporated; Wylie Brown, President of Phelps Dodge Copper Products Corporation; Treasurer, C. T. Ulrich, Vice-President and Treasurer, Kennecott Copper Corporation; Secretary, B. B. Caddle.

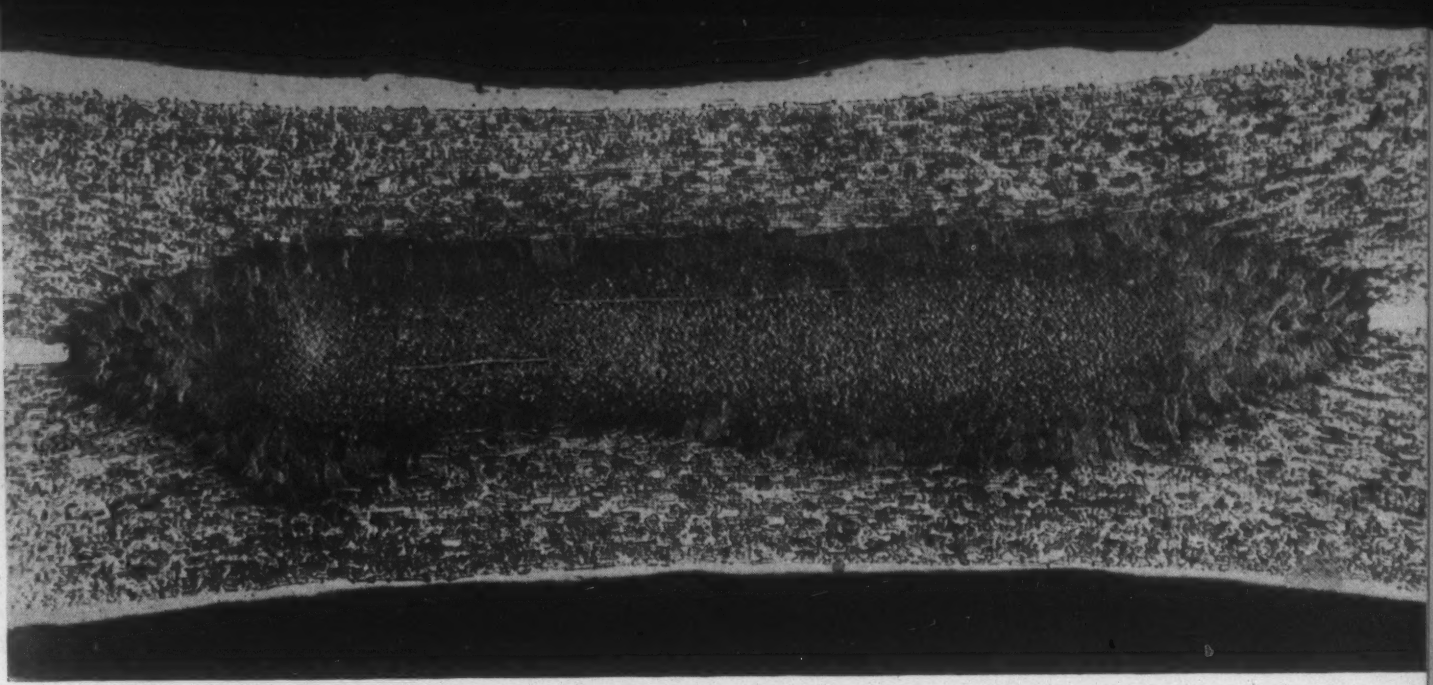
Fred S. Winfield, for the last four years associated with automotive and industrial manufacturing concerns, has joined the field staff of Aluminum Industries, Inc., of Cincinnati, manufacturer of Permite Products, as sales engineer, according to announcement of H. J. Hater, general manager. Winfield will have headquarters at Detroit, as assistant to B. J. Plumley, district manager, and will contact automotive and industrial organizations in Detroit and Michigan.

George L. Craig is now Research Engineer in charge of research and development of the Calumet & Hecla Consolidated Copper Company. He was formerly metallurgist at the Battelle Memorial Institute. He is also a Section Editor of the Abstract Section of METALS & ALLOYS.

H. H. Doehler, President, Doehler Die Casting Co. announces that **Charles Pack** has rejoined the Doehler organization in the position of Assistant to the President in charge of all research and development. Mr. Pack wrote an article on "Press Casting" which appeared in our February, 1932, issue.

Fredolf J. Peterson, Detroit district representative of The Electric Furnace Company, Salem, Ohio, died at his home, 2947 Calvert Ave., Detroit, Mich., Sunday morning, December 2nd, after a brief illness of pneumonia. Mr. Peterson, who was born in Sweden, was 49 years of age and came to this country when 17 years old. He has been associated with The Electric Furnace Company for the past 15 years, 12 years of which he represented the Company in the Detroit district.

A well-made spot weld in an Alclad aluminum alloy.



Some Fundamentals of

SPOT WELDING

Especially of the Light Alloys

By Raymond H. Hobrock *

SPOT WELDING and other resistance welding methods have been known and used in the industry for many years. These methods, depending as they do upon the generation of a local high temperature by the passage of a heavy electrical current through the metal to be welded, developed rapidly with the development of the electrical industry. In general, however, such resistance welding methods up to recent times, have been considered to be applicable only to certain of the ferrous alloys, since these alloys had a property generally known as a "large welding range." By this welding range was meant a temperature range below the melting point, within which it was possible to heat the two pieces of metal to be joined and simply to effect a weld by then pressing them together tightly. Furthermore, these ferrous alloys had such high melting points that the probability of exceeding it at the spot to be welded (and so burning a hole in the pieces) was small. It required but small accuracy in the timing of the weld to prevent this melting; usually the limited capacity of the electrical circuit was sufficient to obviate this difficulty.

Within recent years, however, industry in its general development has had many new types of alloys available for its use. These alloys, both ferrous and nonferrous, are all distinguished by certain desirable characteristics which indicate their use in certain places. In the aircraft industry, especially, the alloys of low specific gravity and high strength were not only indicated, but have made possible the development of both heavier-than-air and lighter-than-air craft to their present state of perfection.

Thus, the older methods of fabrication and of the joining of metals were tried in their application to the light alloys, with the result that great modifications were in many cases found necessary before any results of a usable nature could be reported. The resistance welding of aluminum and the aluminum alloys was found to be commercially very difficult, partly because of its low melting point, of the apparent absence of any welding range, and of low electrical resistance and the ease with which tenacious, high melting point oxides of aluminum were formed at room temperatures.

However, modifications of the apparatus and refinements in technique have, in recent times, led to the production of resistance welds of high quality and fair uniformity. These modifications and improvements have been chiefly directed to the design of proper transformers to supply very heavy secondary currents and to means of controlling very accurately the time during which this current flows.

The aircraft industry, however, has been loath to replace the expensive process of riveting by that of spot- or seam-welding, primarily because there are no sufficient investigations available of the static and fatigue properties of the spot welds and because there is no well-defined technical prescription for the production of such welds of uniform quality. Furthermore, safety in aircraft has been most essential to the industry in all of its aspects, in the development of public confidence and the consequent financial backing and development of the science and art of aviation. It is therefore understandable that relatively untried methods of joining stressed parts should not be generally adopted by the industry without a most thorough knowledge of the properties resulting.

This institute has therefore considered it of importance to investigate in a fundamental and practical way the essential principles involved in resistance welding processes and the realization of these principles in the best way in the technique.

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* Daniel Guggenheim Airship Institute, Akron, Ohio.

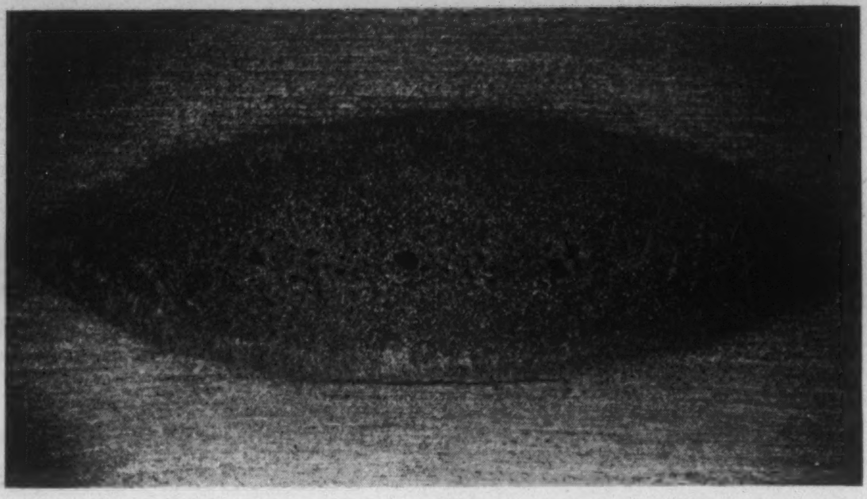


Fig. 1. Cross-section of resistance weld, showing structure differences and cracks.

Electric Resistance Welding

In electrical resistance welding the material at the point to be welded should form the main portion of the resistance in a circuit in which very large currents can be caused to flow. The Joule heat developed by the passage of the current through the points causes the material to rise in temperature. If the current flowing is large, the temperature of the material at the points to be welded increases very rapidly. When the metal has been heated into the plastic range, the weld is effected by pressing the two pieces of metal together. This is accomplished in the spot welding machines by the pressure on the electrodes. The whole process is, in effect, a variation of the well-known hammer welding.

There are three types of resistance welding usually identified; viz. spot welding, seam or roll welding, and butt welding. In this paper, however, only spot and seam welding will be discussed, although many of the principles discussed are applicable to the other type of welding.

In spot welding it is possible to control the maximum temperature, the duration and speed of heating, and the speed of cooling better than in any other welding process. Moreover, the amount of metal heated to the required temperature can be confined to the smallest possible amount; that is, to that portion immediately under and very near to the electrodes. It is therefore to be expected that this process should yield the best possible results of all welding methods.

Yet in spite of these advantages in favor of spot welding, there are also difficulties, especially when the process is to be applied to the welding of aluminum and the aluminum alloys. These difficulties have their origin in

1. The low electrical resistance of the aluminum alloys as compared to the ferrous alloys. This necessitates the use of electrical equipment of high current capacities, since the Joule heat developed is

$$H = I^2Rt$$

in which I is the current flowing,

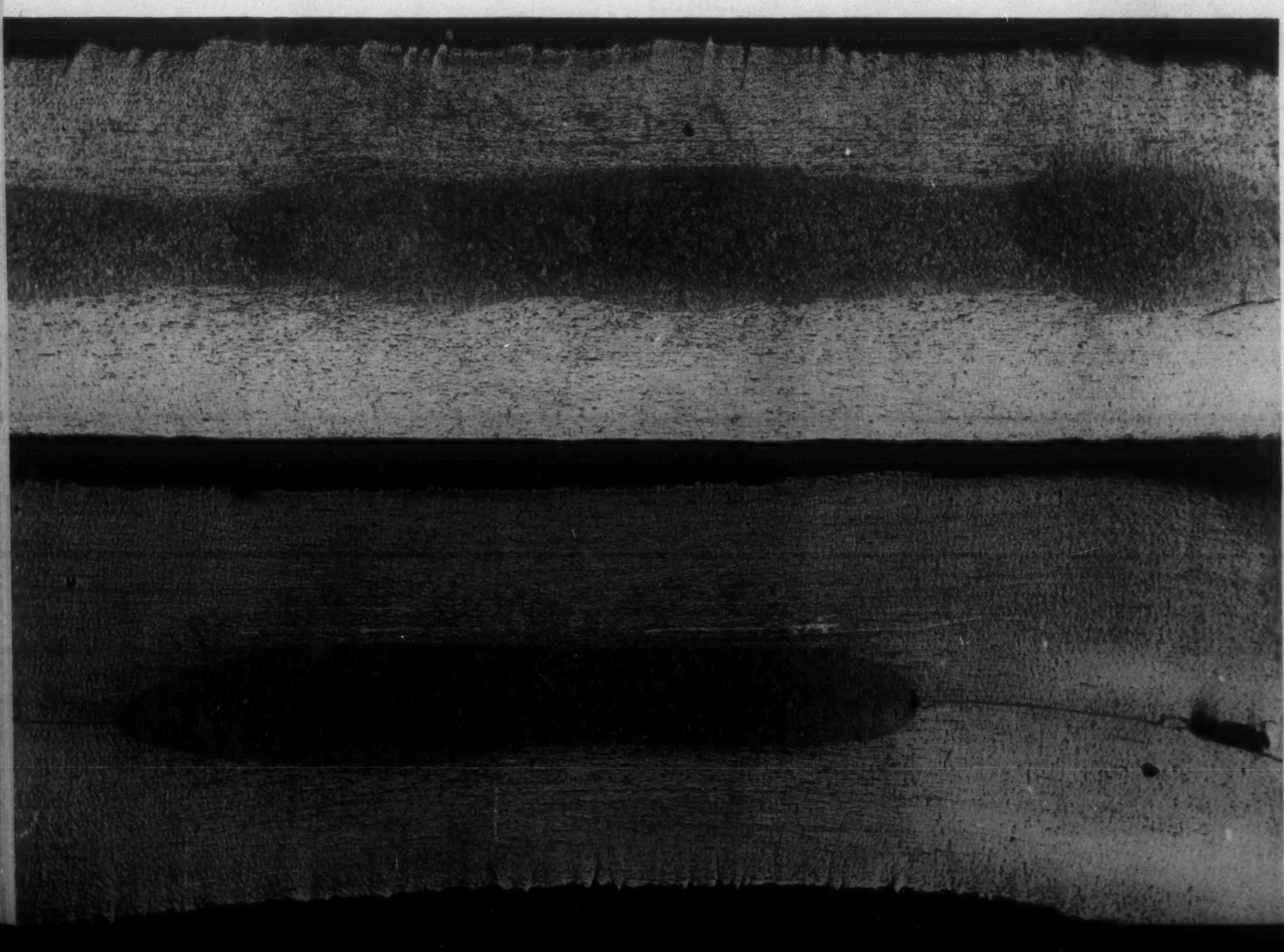
R is the resistance of the metal between the electrodes,

t is the time during which the current flows.

2. The high electrical resistance of the aluminum oxide and its high mechanical strength.
3. The fresh oxidation of the heated aluminum at the weld spots.
4. The facility with which aluminum and many of the aluminum alloys recrystallize to form large crystals at the welding temperature.
5. The small temperature range within which most aluminum alloys can be welded without melting. This latter difficulty can be circumvented by the accurate control of sufficiently large currents in the welding circuit actually to melt a small amount of the material at the point of contact of the two sheets. The melted portion must under no circumstances extend to the electrodes, since then the forces acting because of the passage of the heavy current expel the molten metal from the spot and leave a hole in the sheets. The advantages and disadvantages of spot welding by melting will be discussed in later sections.
6. The high thermal conductivity of aluminum and aluminum alloys.

Analysis of the Process of Welding Below the Melting Point

What is understood under the term "welding"? If the older literature is investigated, one finds some such



Sections of well-made seam welds in an aluminum alloy. Above is cross section; below is longitudinal section.

typical definition as this:[1] "White hot iron may be joined to another piece of iron, which is also in the white hot condition, by mechanical pressure. One calls this process of joining the two pieces 'welding.'" The requirements for welding were a proper temperature and mechanical pressure on the pieces.

The meaning of the term has, however, been extended so that it now includes processes in which two pieces of material are joined by melting along their faces of separation without any special pressure being applied.

Electrical resistance welding methods have aimed at effecting a union between two pieces by mechanical pressure within a certain temperature range known as the plastic range, or the welding range. Melting of a portion of the metal, especially in the case of the aluminum alloys, is to be avoided.[2]

1. because of the danger of melting the spot to the surface (especially in the thinner gages of metal);
2. because the material in the spot will then freeze in the cast structure and lose all of the desirable properties gained through the previous cold working;
3. because in the freezing from the molten condition minute contraction cracks might easily be formed, which would be dangerous points of stress concentration, and, although they might not affect the static strength properties of the welded pieces, might materially decrease their fatigue properties; and
4. because subsequent aging (precipitation hardening) is not as effective in cast material as in worked material. Furthermore, the rapid transition between two dissimilar structures—that is, a cast structure immediately bordering on a rolled structure—provides an undesirable surface of potential weakness, as well as a point at which corrosion might proceed rapidly because of the formation of an electrical couple due to the differences in the internal energies of the cast and rolled structures.* See Fig. 1.

It is therefore of importance to examine carefully the mechanism of welding in the plastic range and to determine quantitatively, if possible, the effect of the two chief conditions of mechanical pressure and temperature on the process of welding and on the properties resulting from the practical application of the information gained.

Exactly what happens when two pieces of metal are welded together in the plastic range? An old explanation has it that the mechanical pressure or working (hammering, rolling, pressing) caused a small portion of the already hot metal to melt at the interface—perhaps because the work done in friction between the two faces was changed into heat—this melted metal then solidified and bound the two surfaces together.

H. Esser[4] has made a study of the pressure welding of electrolytic iron and several steels in vacuum. He found that it was possible to make a weld in electrolytic iron at 800° C. with a pressure of 3 kg/mm.^{2} If a stress-strain curve for electrolytic iron at 800° C. is examined and the total work done is calculated from the deformation and loading, and if it is further assumed that the entire mechanical work done is transformed into heat, the amount of heat developed through this deformation would not be sufficient to raise the temperature of a mass of iron the thickness of an average grain boundary in the metal from 800° C. to the melting point. It seems improbable, therefore, that this explanation of the welding process can present a true picture.

It is suggested, therefore, that the welding process has its basis in the recrystallization of the metal. The pressure required in the process serves several purposes:

1. It presses the surfaces of the two metals close together;
2. It breaks through the films of oxide, nitrides, and adsorbed gases that are found on the surface; and
3. It provides a small deformation in the crystals of the original material that will permit them to recrystallize. During this process of recrystallization the grains may then grow across the boundary (interface) that separated the two pieces. If this grain growth occurs, the two pieces are welded together.

According to this explanation, welding depends essentially upon recrystallization. Recrystallization, on the other hand, is dependent on deformation and temperature. The correlation between the size of the crystals formed by recrystallization, the temperature at which the recrystallization is carried out, and the amount of deformation (cold permanent deformation) is shown in the three-dimensional recrystallization diagrams of Figs. 2, 3, and 4.

Recrystallization

Recrystallization is the growth of crystals of different size and different orientation from the original crystals that make up a crystalline solid, at temperatures below the melting point. Technical metals are made up of a conglomeration of crystals with different orientations. These separate crystals are ordinarily known as grains. Since the atoms of the metal in each separate grain have distinct configurations and orientations, it is obvious that where two such crystal faces meet in a metal there are regions of disorganization of the atoms. At the interface in a polycrystalline pure metal, there are atoms that do not fit exactly into the oriented systems of either of the two crystals. The potential energy of these disorganized atoms is greater than those of the other atoms—they will therefore be attacked more readily by etching reagents. This occurs in etching specimens for the microscope (grain boundary etching).

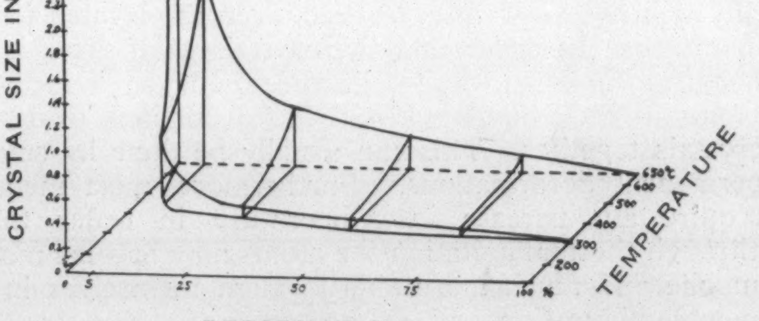


Fig. 2. Recrystallization diagram for pure aluminum. (Rassow & Velde. *Zeitschrift für Metallkunde,* 1921.)

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[1] C. J. B. Karsten. System der Metallurgie, 5 Vols. G. Reimer, Berlin, 1831.

[2] F. Goldmann. *Hauszeitschrift der V. A. W. Ertfwerk,* Vol. 1, 1929, page. 265.

[*] G. Tammann[3] has shown that in the case of copper there may be as much as 9 millivolts potential difference in the cell

$$\text{Cu (hard) / 1 n } CuSO_4 \text{ / Cu (soft)}$$

in which the hard sheet of copper is the less noble of the two elements. In his determinations only the surface of the copper was hardened by polishing it with polishing paper. After the thin cold-worked surface had been dissolved away, the potential of the cell became zero.

[3] G. Tammann. Lehrbuch der Metallkunde. L. Voss, Leipzig, 1932.

[4] H. Esser. *Archiv fuer das Eisenhuettenwesen,* Vol. 4, 1930, page 199.

This conception of a disorganized layer of atoms between crystals leads to a picture of recrystallization. In a pure polycrystalline material some of the crystals would grow at the expense of others. It is known that many crystals grow more rapidly along one of their crystallographic axes than along others. It can therefore be assumed that the forces acting to orient the atoms in one direction are greater than those in another direction. In a polycrystalline material those crystals with orientations favorable may arrange the disorganized layer of atoms in the interface according to their own configuration. This, however, would immediately produce another interface of disorganized atoms, which would in turn be oriented. It is thus conceivable that the polycrystalline material would decrease in the number of its crystals and eventually form a single crystal.

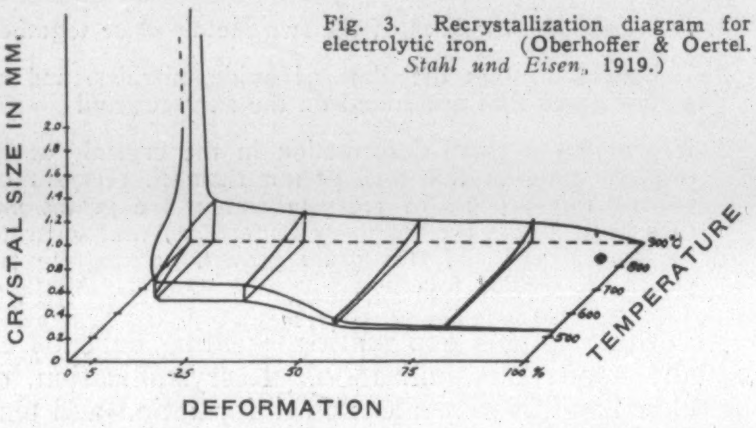

Fig. 3. Recrystallization diagram for electrolytic iron. (Oberhoffer & Oertel. *Stahl und Eisen*, 1919.)

However, most of the materials (and certainly most of the metals) are not pure enough thus spontaneously to recrystallize. There are, in metals, a number of foreign atoms as alloying elements, and as impurities in the way of absorbed gases and other impurities, that do not fit well into the crystal configuration, no matter how oriented. These atoms are usually rejected as the crystal grows from the melt and are finally trapped in the grain boundaries. Thus the metals usually will not grow in grain size, even at elevated temperatures. In order that the crystals shall grow it is necessary in some way to puncture the layer of foreign atoms in the boundaries and bring portions of pure crystals together. This can usually be done by small permanent deformations. Furthermore, most metals require an increase in temperature in order that through thermal agitation the atoms may become more mobile and much more able to align themselves in a new configuration.

If the proposed explanation of welding below the melting point is true, it follows that all metals which exhibit recrystallization can be welded in this way. It is well known that a large number of metals can be welded by heating and deforming; however, aluminum and aluminum alloys have usually been considered to be metals that cannot be so welded.

Heraeus[5] has produced forge-welded apparatus of commercially pure aluminum for many years (German Patent No. 118686). Large tanks and vats designed to be used in the chemical industry, where riveting and other methods of welding produced sufficient inhomogeneity to cause local couples and rapid corrosion, were forge-welded by heating the joints with a torch to a temperature at which the aluminum became soft and then hammering the two pieces together. The process requires careful manipulation of the heating so that the aluminum is not melted and yet is brought into the soft range of temperature. F. Goldmann[2] specified the temperature at which aluminum could be forge-welded as 450° C. The welded seam as well as the region around the weld that has been heated during the process, is hammered well with round hammers during cooling, in order to prevent a large grain growth and in order to restore the higher strength properties due to cold-working of the original sheet. Such welds have been shown to be of the highest quality during years of use.

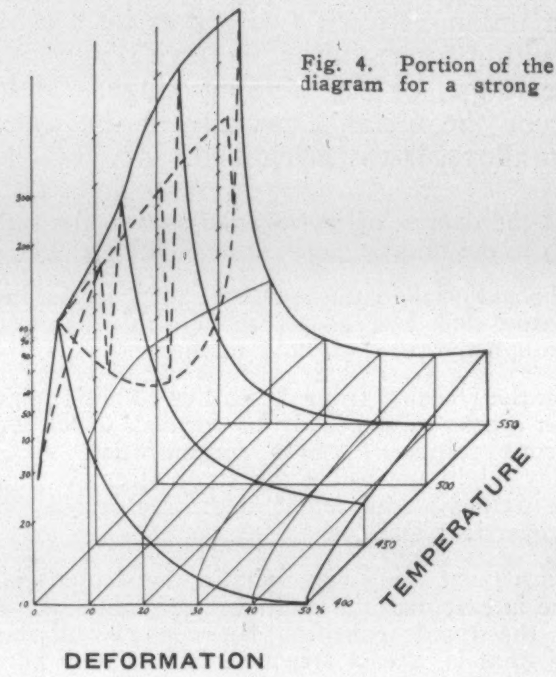

Fig. 4. Portion of the recrystallization diagram for a strong aluminum alloy.

However, the forge-welding of some of the aluminum alloys presents a greater difficulty. Their melting points lie below that of pure aluminum, so that the temperature range in which they may be forge-welded is considerably decreased (see Fig. 5). The cooling curve for Silumin, a German alloy with about 13% silicon and the rest aluminum, is shown in Fig. 5c. Its composition is so chosen as to be about of eutectic proportions, so that it has a sharp melting point. There are no second melting points at lower temperatures.

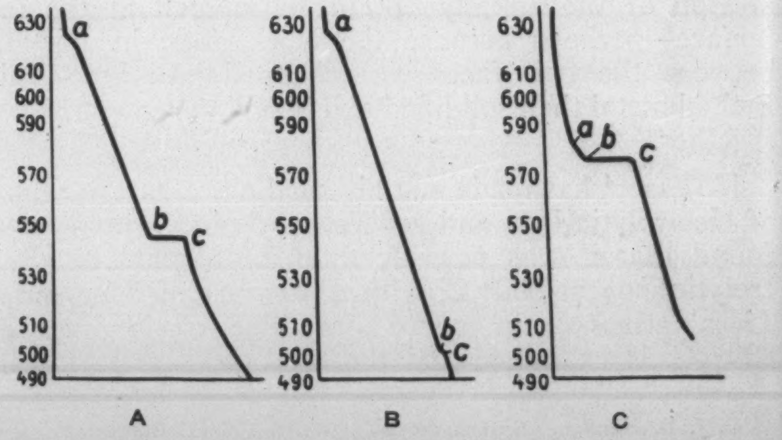

Fig. 5. Cooling curves for various aluminum alloys. Curve b) corresponds closely to a typical American strong alloy. Curve c) is for the German alloy Silumin.

The temperature at which the material with the lowest melting point freezes determines the upper limit of temperature that can be used for hammer-welding. Above this the low melting point material usually found in the grain boundaries has melted and the entire alloy becomes mushy—it does not have sufficient strength to withstand the working necessary for the welding. Silumin therefore is one of the aluminum alloys that may be hammer-welded with little difficulty.*

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[5] Heraeus, G. m. b. H. *Hauszeitschrift der V. A. W. Ertfwerk*, **Vol. 1, 1929, page 262.**

However, in the examination of an aluminum alloy containing 4% Cu, 0.5 Mn, 0.5 Mg, remainder Al, recrystallization was found to occur at temperatures as low as that of the room. It therefore should be possible to weld such an alloy at temperatures well below the melting point, provided the oxide layer between the two pieces to be welded could be broken through sufficiently and provided that the recrystallization could be made to occur largely at the interface between the two specimens.**

Experiments were therefore made*** in which two pieces of the aluminum alloy were held in a clamp, shown in Fig. 6, and the whole arrangement heated in an electric furnace to the indicated temperatures. When the desired temperature had been reached, the specimens were pressed more tightly together and deformed by tightening the screw. The whole was then allowed to cool somewhat in the furnace, the specimens removed, and microsections prepared.

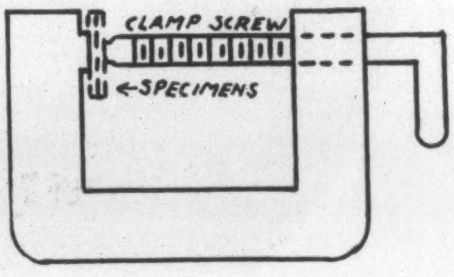

Fig. 6. The clamp was used in making the experimental welds.

Figs. 7 to 10 show the results of these experiments. The micrograph, Fig. 10, shows a complete disappearance of the line of separation between the two pieces at the point where the deformation had been made, even though the temperature at which the experiment has been carried out was well below the melting point of the material. These experiments show that at least for the alloys investigated, it is possible to hammer-weld the metal.

A group of further experiments was undertaken with a spot welding machine. The welder was so adjusted that the spots were definitely melted in the first series. Then the current was successively decreased until the two pieces no longer stuck together. The structures of such welds are to be seen in the photomicrographs in Figs. 11 and 12. No precautions were taken about the shape of the electrodes used in the welding transformer, so that the welds shown in the above-mentioned figures are not representative of the most desirable shape of the welded spot.

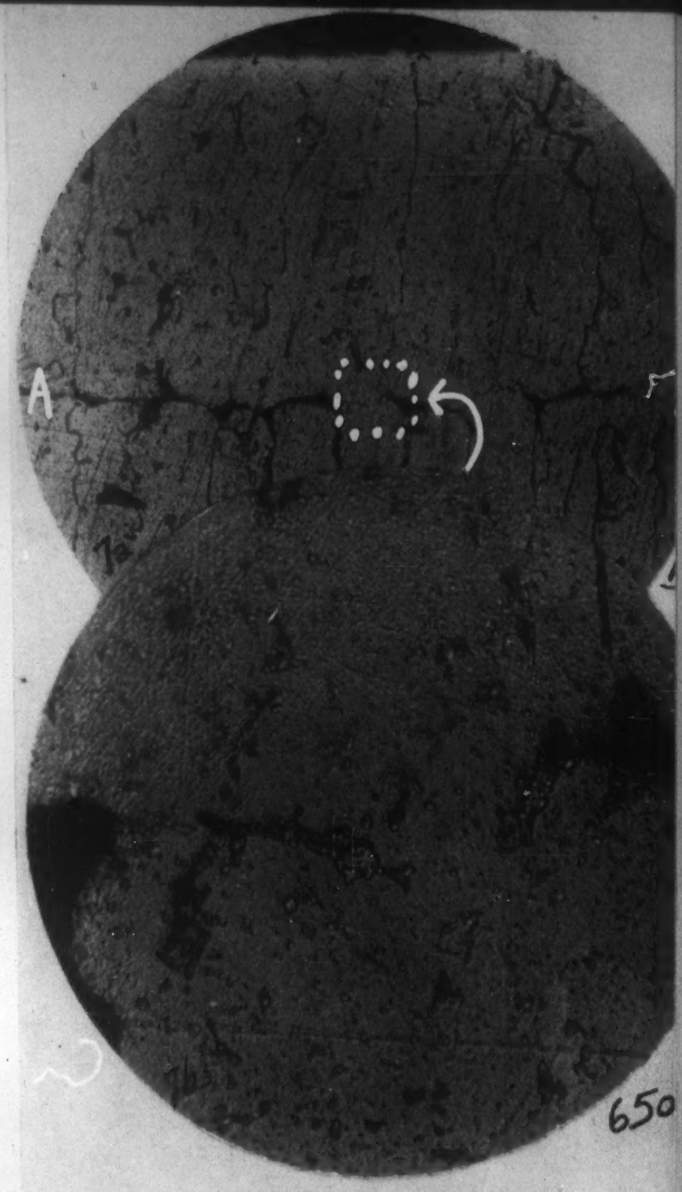

Fig. 7. a) upper 50×. b) lower 650×. Sample of an aluminum alloy (1.25% Mn, 1% Mg, remainder Al) welded at 600°C. Note growth of some of the crystals across line of separation in 7-a). 7-b) shows details of the portion indicated in 7-a). The growth of the crystals across the boundary of separation is seen. Note also the remnants of boundary of separation. These boundary remnants contain foreign materials, such as oxides, etc., that collect together due to surface tension if sufficient time is allowed at a proper temperature.

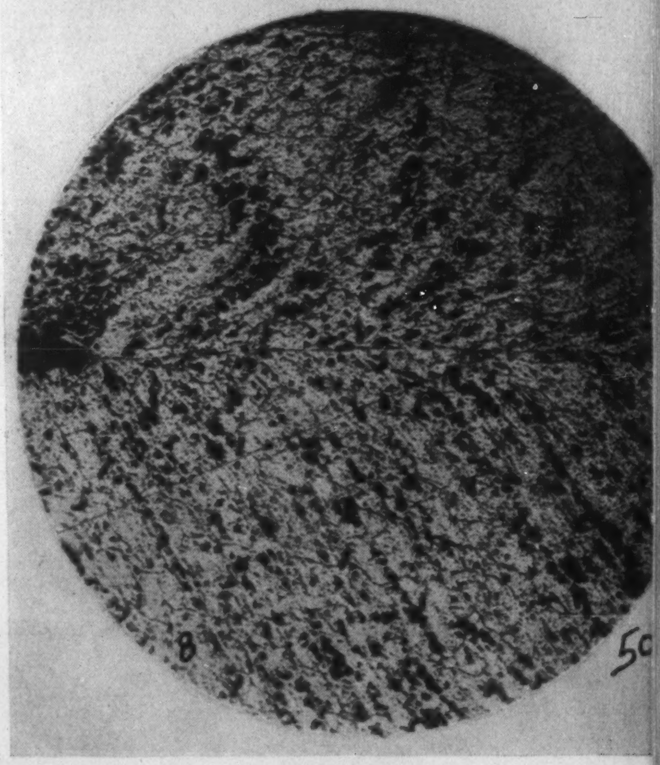

Fig. 8. 50×. Another sample of same metal as shown in Fig. 7, but welded at 585° C.

The difference in the structure of a weld made by melting the metal and one made by recrystallization is brought out very well by the photomicrograph of the longitudinal section of a seam weld, shown in Fig. 13. The timing of the weld is indicated below, while an X-ray diffraction diagram of the spot marked in the photomicrograph is shown above.

Since the electrodes are, of course, different for seam welding than for spot welding (disc electrodes), the structures will be different, depending upon the different temperatures and pressures. It is seen that the most homogeneous portion of the weld has occurred, not directly under the electrodes, where the temperature was highest, but rather in that region toward the edge of the electrode, which had been heated

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* Comparison of samples of Silumin autogeneously welded and hammer-welded shows the following results on soft annealed sheet: [6]

	Maximum Strength kg./mm.^{2}
Hammer-welded	15.8
	16.0
Autogeneously welded	14.3
	14.0

** The phenomenon of welding by recrystallization at room temperature is one often observed in connection with the low melting point bearing metals. Lacking sufficient lubrication—that is, lacking some means of separating the interfaces by some substance not crystallizing at room temperature—the bearings "freeze"—they grow together by recrystallization. Tammann [3] has shown that carefully polished pieces of lead may be caused to grow together by pressing them together with the hands. These pieces later pulled apart did not separate along their original faces.

*** Much of this experimental work was carried out by Mr. Luc Secretan of our laboratory.

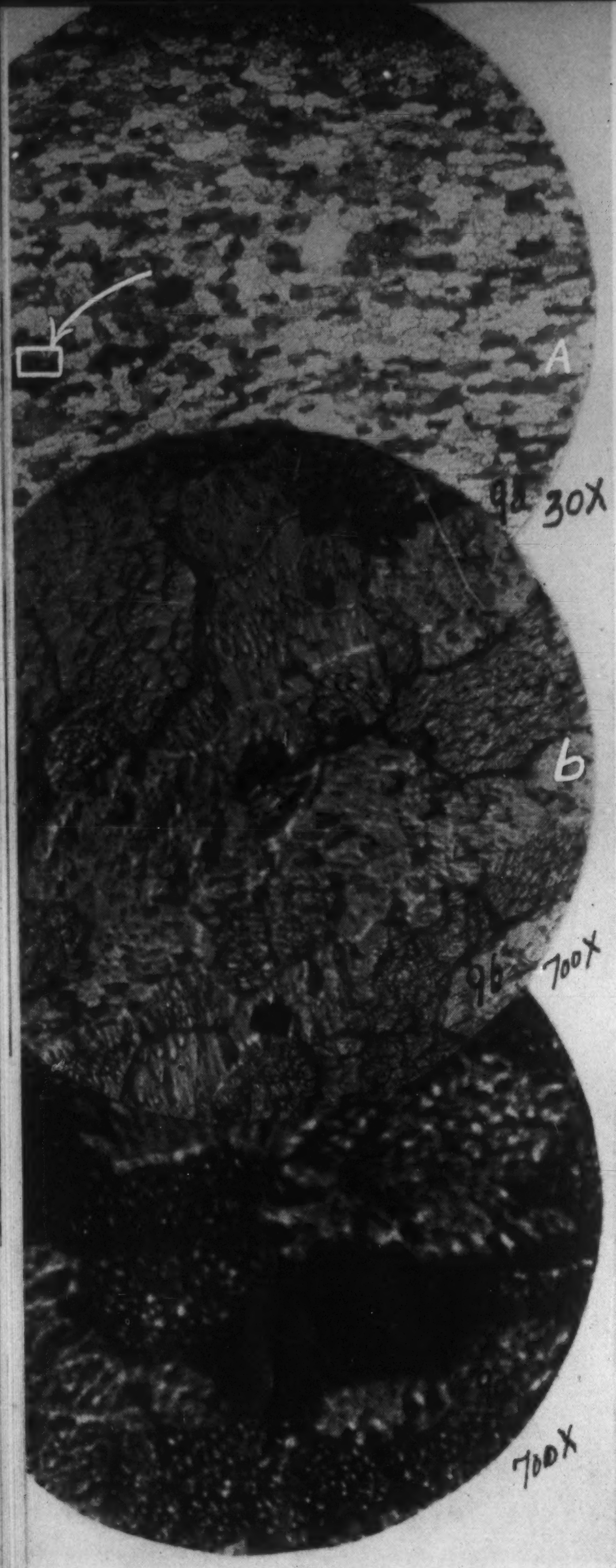
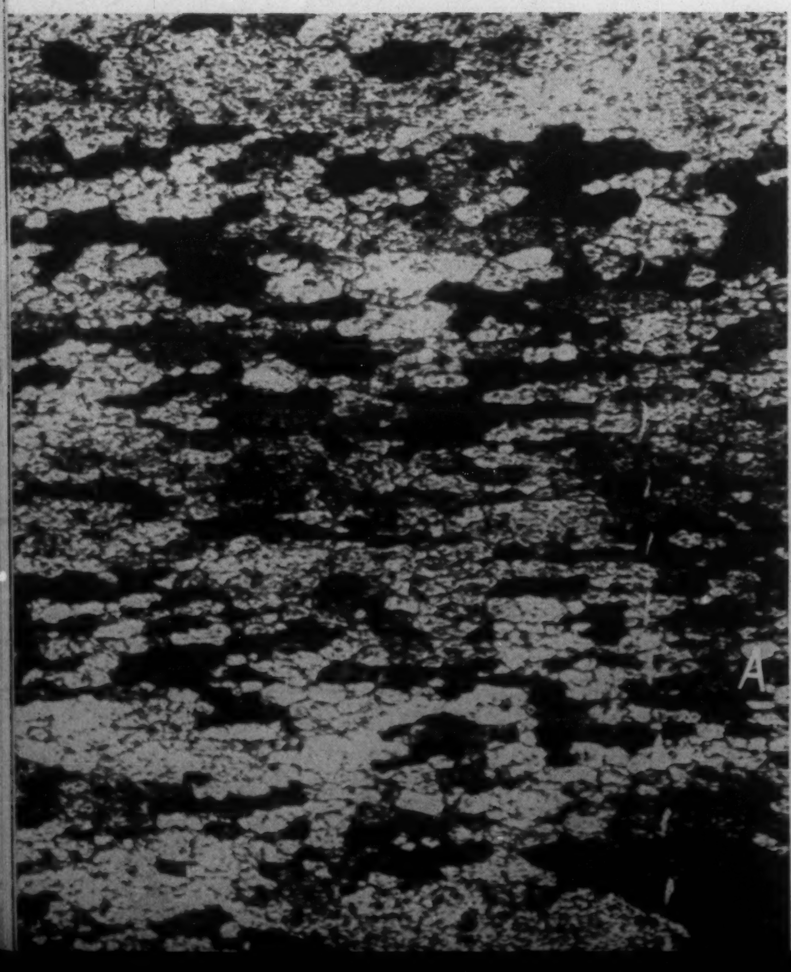
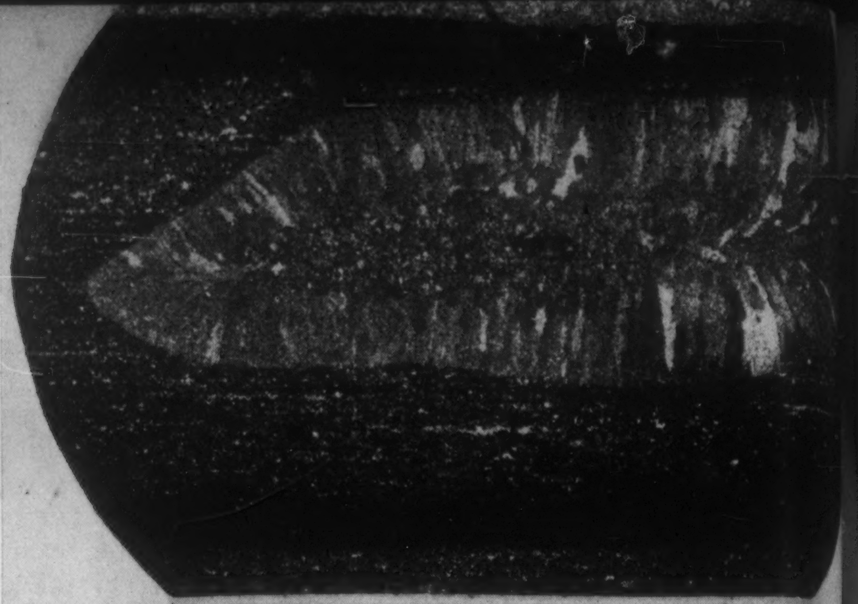


Fig. 9 a). 30×. A sample of a strong aluminum alloy (4% Cu, 0.5 Mn, 0.5 Mg, remainder Al) welded at 560° C. Note complete growth of crystals across former separating face a-a. The high magnification pictures 9 b) and 9 c) are from a series of pictures made in the region indicated in 9 a), and show the disappearance of the plane of separation.

Fig. 9 b), center and 9 c), lower. 700×. 9 c) shows the portion not subjected to pressure in the clamp. The plane of separation is still seen. 9 b) shows the portion subjected to pressure. The plane of separation has disappeared. Crystals have grown completely across the former face of separation, b-b.

Fig. 10. Same material as indicated in Fig. 9. Welded in clamp at 540° C. Crystals have grown across the previous plane of separation, a-a.





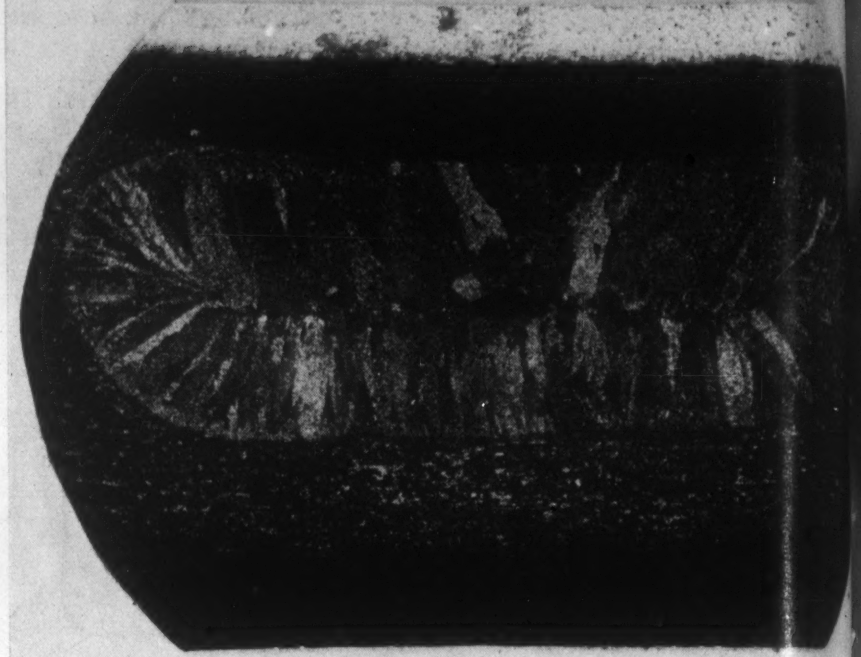
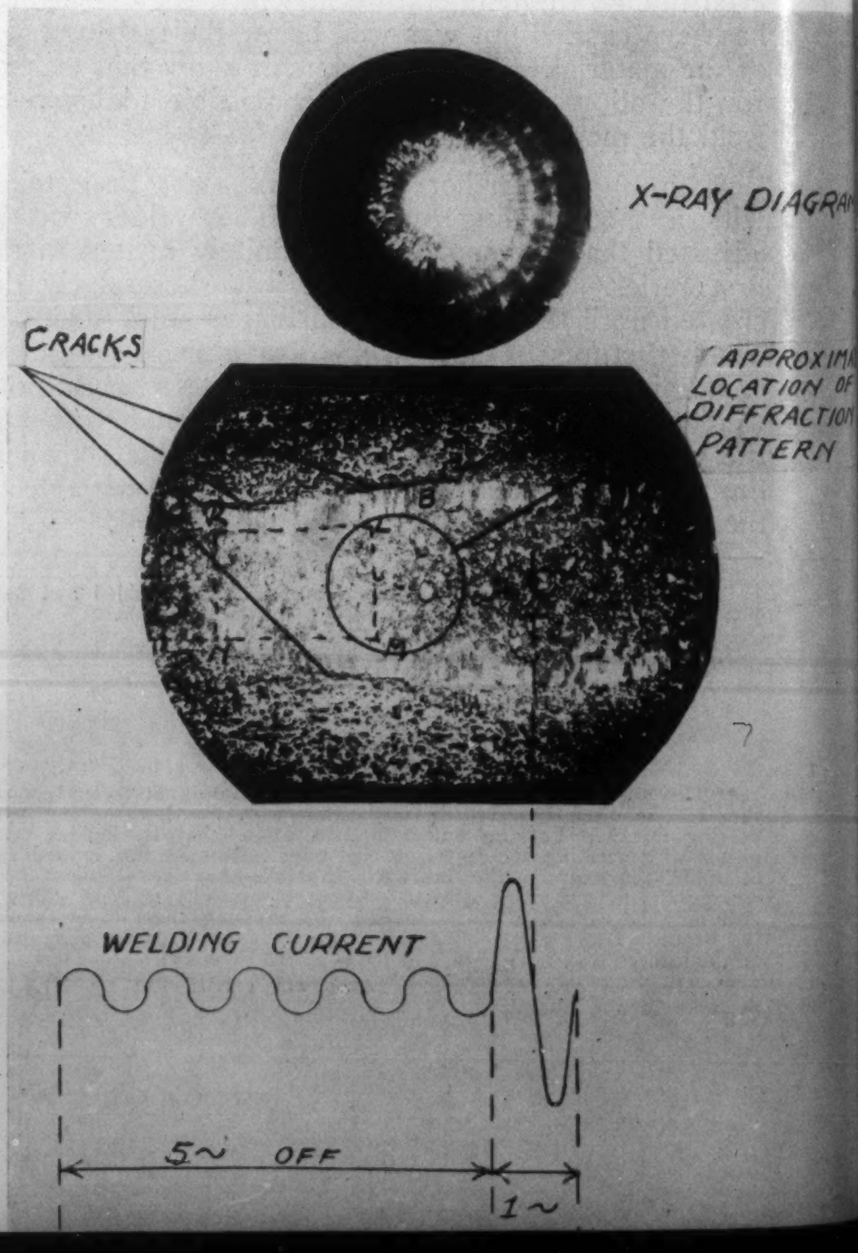


Fig. 11. (Upper). Spot weld in an aluminum alloy. Center portion has been melted.
Fig. 12. (Lower). Spot weld in an aluminum alloy. There has been no melting.

Fig. 13. Longitudinal section of a seam weld in an aluminum alloy. The timing is indicated below. Note the porosity in the portion below the electrodes, where the welding current flowed. Also note recrystallized portion where no current flowed. Specimen over-etched to bring out contrast.



by only a small portion of the current and by the conduction of heat from the neighboring welds.

The portion directly under the electrodes had been melted. It froze from the molten condition very rapidly, producing a multitude of very fine crystals with little or no remaining stresses. On the other hand, the recrystallized portion (K-L-M-N) is seen to be of a rather uniform structure, with no gas or contraction holes. The crystals are larger than those in the cast structure, but retain some of the properties of worked metals. The inner ring of streaks in the X-ray diagram is due to this recrystallized portion—it shows asterism, which here is indicative of internal stresses. This internal stress may be the result of unrelieved original internal stresses, or might have been caused by the working of the electrodes on the metal as it cooled.

The cracks shown in the photomicrograph are very likely due to the fact that when the current flowed and melted the portion immediately under the electrodes, the surface of the sheets was pressed in. This produced a bending, resulting in tension at that portion which had been recrystallized. But the recrystallized portion was at a sufficiently high temperature to have but low strength properties. It therefore parted at the separation plane between the original material and the recrystallized section.

(Continued in February issue)

NEWS

G. G. Coolidge was elected a Vice-President and a Director of the Harbison-Walker Refractories Company. Soon after graduation from Yale University in 1904, Mr. Coolidge became connected with the D. L. & W. Railroad Company and later with the Westinghouse Air Brake Company. In 1906 he became a member of the Pittsburgh District Sales Office of Harbison-Walker Refractories Company. He was made District Sales Manager of the Pittsburgh District in 1911, Assistant General Sales Manager in 1924 and Assistant to the President in 1929.

Alexander Blackwood, internationally known steel foundry expert, who has specialized in the manufacture, heat treating and marketing of high and low alloy steel castings, has been appointed General Manager of The Dayton Steel Foundry Company, Dayton, Ohio, and will have direct charge of the manufacture, heat treating and marketing of alloy steel castings, stainless steels and heat resisting alloy castings.

F. A. Hansen, previously General Manager of the Hevi Duty Electric Company, is now in charge of the engineering and production of the new Lindberg Control instruments.

Herbert J. Beck, director, assistant treasurer and factory sales manager for Aluminum Industries, Inc., of Cincinnati, died suddenly at the Company's office Friday, December 14th. Many months spent in government hospitals and at Mayo Brothers had failed to effect a permanent cure of ailments which had resulted from gas and shrapnel wounds sustained during the World War. For the past two years he had been in poor health. Beck had been with Aluminum Industries since the Company was formed and was known widely throughout the industry. He was 39 years old and a native of Cincinnati. He was buried in St. Mary's cemetery in Cincinnati, Monday, Dec. 17.

General Refractories Company, Philadelphia, announces the appointment of Collinwood Shale Brick & Supply Company, Cleveland, as Dealer-Agents in the Cleveland area.

The 144th Meeting of the American Institute of Mining and Metallurgical Engineers will be held in the Engineering Societies Building, New York, N. Y., Feb. 18-21. An extensive program of technical papers has been prepared for all the various divisions of the Institute.

For the Iron and Steel Division an unusually broad program has been scheduled for Feb. 18th to 21st. Nine sessions have been arranged, covering the usual topics. A special session is devoted to sponge iron. The regular luncheon will be held Feb. 20 and on the following day its executive committee will meet at 5 p. m. The Howe Memorial Lecture will be delivered Feb. 20th at 4 p. m. by Earl C. Smith, Chief Metallurgist, Republic Steel Corporation.

The Institute of Metals Division will hold its usual sessions on Feb. 19 to 21, for which some valuable papers have been secured. At the Division's regular dinner the customary address will be delivered by D. J. Macnaughtan, Director of Research, International Tin Research and Development Council, London, England, on "The Properties and Uses of Tin."

A feature of the week is a symposium on "The Use of Metals in the Petroleum Industry" which will be participated in by both of these divisions of the Institute. It is scheduled for the morning and afternoon sessions of Feb. 21.

The Editorial Advisory Board of METALS & ALLOYS will meet at a luncheon at the Engineers' Club, Feb. 21.

Reports on metallurgical investigations made at the **Carnegie Institute of Technology** during the past year will be given at the eighth annual open meeting of the Metallurgical Advisory Board to be held Friday, February 8, on the Carnegie campus. Approximately 400 metallurgists are expected to attend the meeting.

Dr. John Johnston, director of the department of research and technology of the U. S. Steel Corporation, will preside at the morning session, and Dr. Frank N. Speller, chairman of the Advisory Board, will give the address of welcome. Drs. Johnston and Speller are members of the METALS & ALLOYS editorial advisory board.

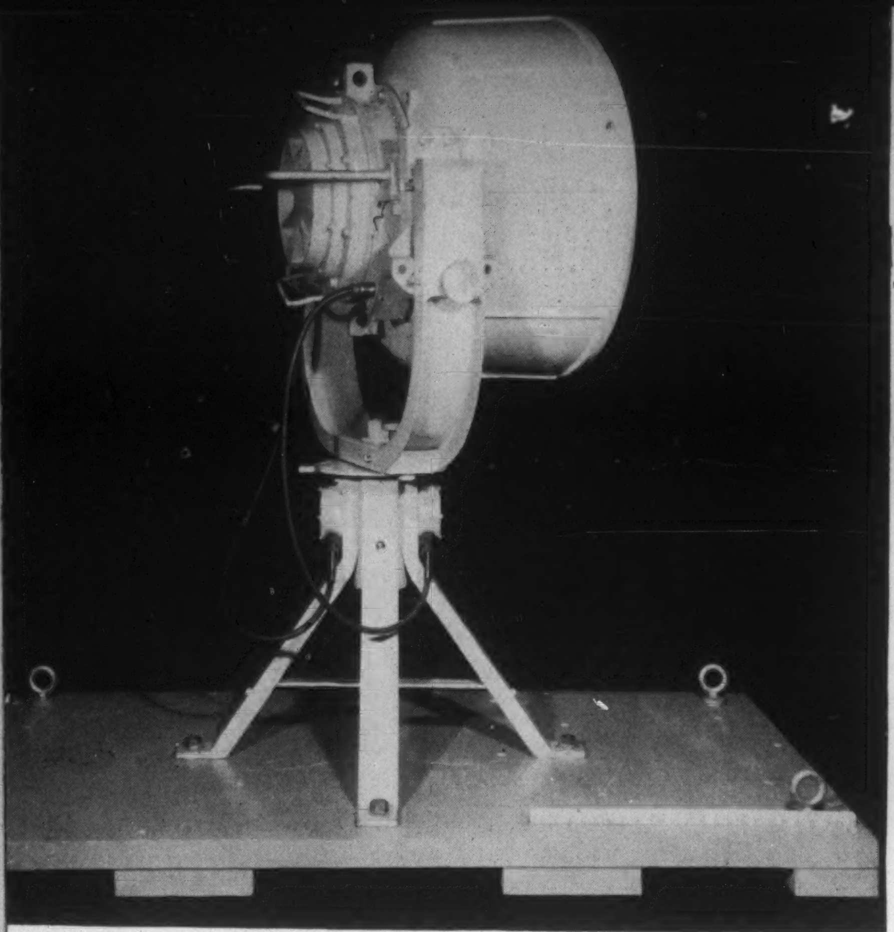
Progress made by the Metals Research Laboratory at Carnegie Tech in theoretical investigations will be reported by the director, Dr. R. F. Mehl. The various projects now being studied in the laboratory are classified under four major heads, namely, plastic deformation of metals, precipitation from solid solution, oxidation of metals, and diffusion in metallic alloys. Dr. F. M. Walters, Jr., formerly of the staff of this laboratory, will offer a final report on the alloys of iron, manganese, and carbon, which he investigated for a period of several years at Tech.

Dr. Cyril Wells, also of the metals laboratory, will explain the preparation and properties of high purity iron and will report on a study of the constitution and properties of a pure sample. The final report of the morning session will be read by B. N. Daniloff, research fellow, on "The Effect of Deoxidation on the Ageing of Mild Steels."

At the afternoon session at which H. W. Graham, general metallurgist of the Jones and Laughlin Steel Corporation, will preside. Dr. Charles H. Herty, Jr., research department, Bethlehem Steel Co., formerly director of research for the Metallurgical Advisory Board, will report on all the studies which were made under his direction at Carnegie.

These reports will conclude the program of research on the physical chemistry of steel-making which has been carried out for the past eight years by the Metallurgical Advisory Board. The subjects of the reports to be given by Dr. Herty include, "The Effect of Deoxidation on the Impact Strength of Carbon Steels at Low Temperature;" "Rate of Transformation and Grain Sizes;" "Deoxidation of Steel;" and "The Control of Iron Oxide in the Basic Open-Hearth Process."

The Brown Instrument Company, Philadelphia, announces a consolidation with the **Minneapolis-Honeywell Regulator Company,** Minneapolis. The Brown Instrument Company will continue as a separate company with its existing organization but as a subsidiary of Minneapolis-Honeywell Regulator Company. Richard P. Brown will continue as President of The Brown Instrument Company and will become an officer and director of Minneapolis-Honeywell Regulator Company. The Brown Instrument Company sales and service facilities will be continued from the present main office and factory at Philadelphia and the district offices located throughout the country.



This loud speaker has a maximum acoustic output of 500 watts. It has a magnetic circuit principally of cast iron with pole tips of an iron cobalt alloy which has very high permeability at high flux density

MAGNETIC MATERIALS

A Survey in Relation to Structure

By W. C. Ellis* and Earle E. Schumacher*

Part 2

(Part 1 printed in December, 1934)

Hard Magnetic Materials (Permanent Magnets)

Permanent magnet materials, as pointed out in the introduction to this paper, are characterized by properties different from those of the soft magnetic alloys. With these materials, a high residual induction and high coercive force are required. Permanent magnets in use commercially at this time are steels. High intrinsic induction is assured by a high proportion of iron in the composition; the magnetic hardness is assured by the addition of carbon, which, when the steel is suitably heat-treated, precipitates as a finely dispersed carbide throughout the matrix. This finely dispersed precipitate keys the structure and furnishes resistance to change in magnetic condition, a property which is measured as coercive force.

Permanent Magnet Steels

Many types of steel have been developed for magnet applications.[28] The most important commercial ones are carbon-manganese, 1% and higher chrome steels of which 3.5% chrome is typical, tungsten steel, and 35% cobalt steel. Typical magnetic characteristics and required heat treatments are shown in Table I.

The heat treatment for the permanent magnet steels consists of a quench from a high temperature at which the carbon is in solution. During the period of cooling in the quench, the supersaturated solution precipitates the carbides. This is designated "quench hardening." The quenching treatment varies with the type of steel, but in general, quenching in either oil or water is used. In this connection, it is important that the austenite transformation occur during the quench, since austenite is non-ferromagnetic and its presence will result in low values of residual induction.

The carbon-manganese and 1% chrome steels are the least expensive and enjoy a large use in low cost apparatus where space requirements are liberal. Typical values for coercive force and residual induction for these materials are 40-50 oersteds and 9000 to 9500 gauss. The 1% chrome steel has the advantage over the carbon-manganese steel in that the desirable

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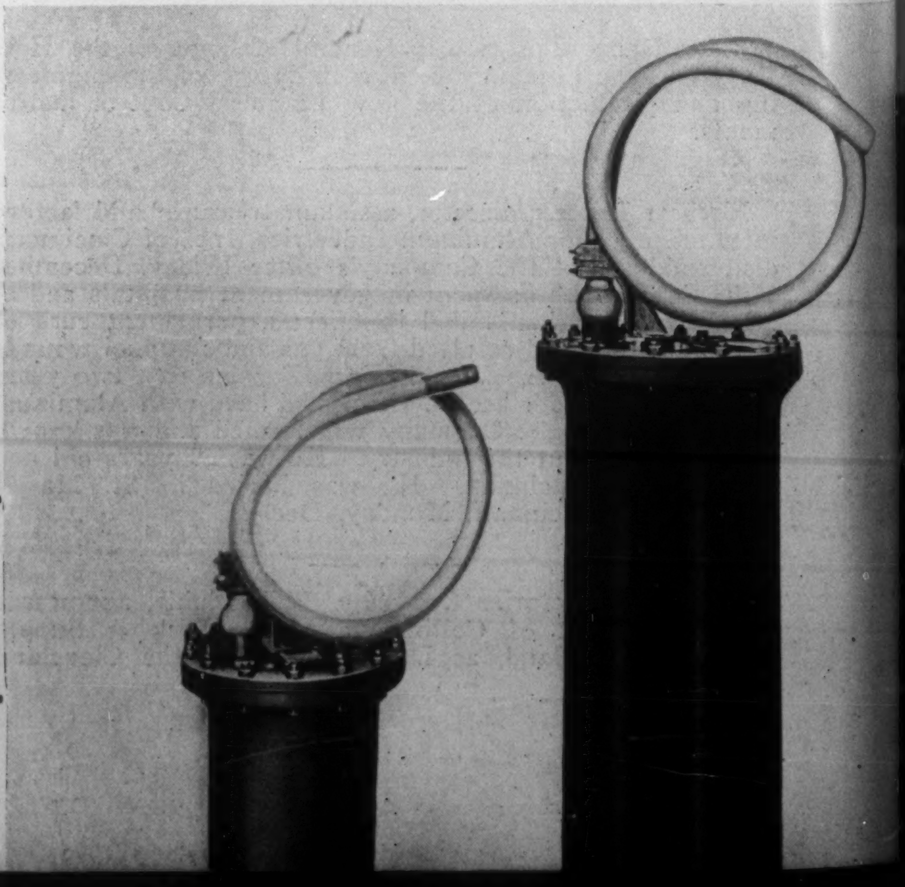
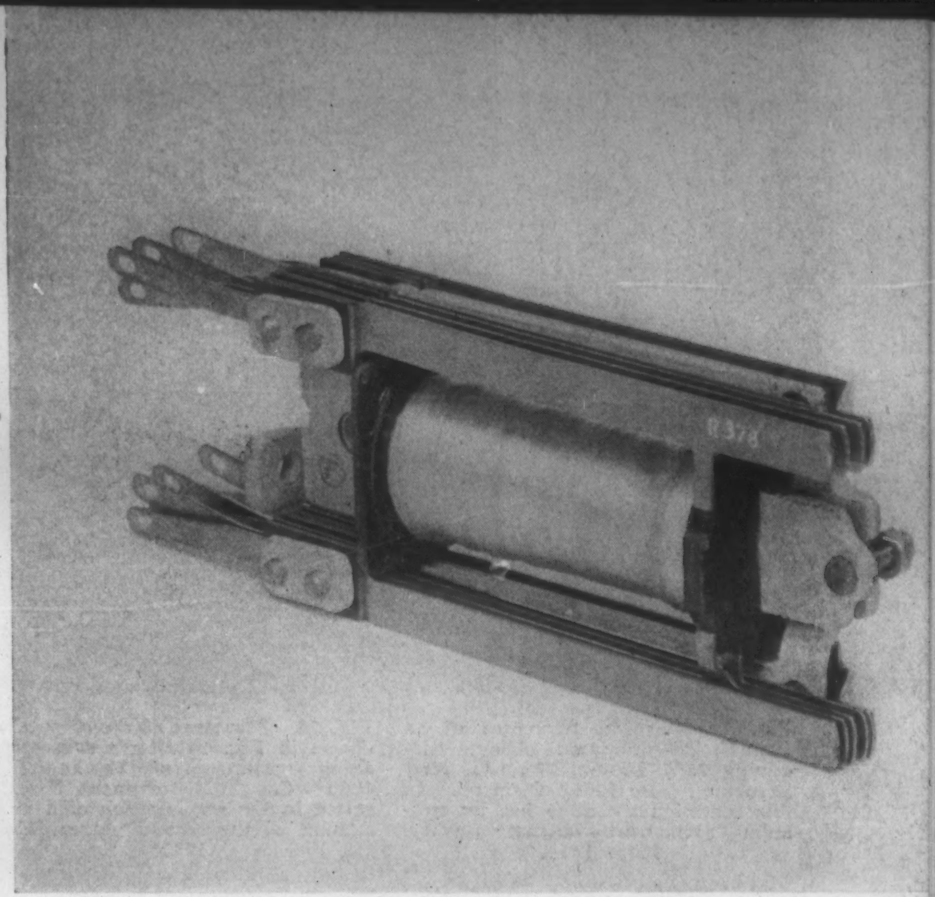
* Bell Telephone Laboratories, Inc.

Table I. The Properties of Permanent Magnet Steels

Type of Steel	Typical Composition %	Heat Treatment	Magnetic Characteristics H_c	Magnetic Characteristics B_r	Magnetic Characteristics $H_c \times B_r \times 10^{-3}$
Carbon-Manganese Steel	C —0.60 Mn—0.80 Si —0.20	Quenched 800°C. in water	40	9000	360
Low Chrome Steel	Cr —0.90 C —0.60	Quenched 800°C. in oil	50	9500	475
3.5% Chrome Steel	Cr —3.5 C —0.90	Quenched 830°C. in oil	68	9500	645
Tungsten Steel	W —5.0 C —0.7	Quenched 845°C. in water	60	10500	630
35% Cobalt Steel	Co —35 W —7 Cr —4 C —0.75	Quenched 940°C. in oil	220	9500	2090

The difference in size between loading coils with cores of permalloy and of iron dust is shown by the size of the loading coil pots which contain them





An R type telephone relay showing the punched steel magnetic structure

characteristics are produced by oil quenching while the carbon-manganese steel is ordinarily water-hardened. Water-hardening frequently results in cracked magnets and consequently a higher proportion of rejections.

Of slightly higher quality are the 3.5% chrome and the 5% tungsten steels.* Typical values of coercive force are from 60 to 70 oersteds, and of residual induction from 9500 to 10500 gauss. In general, tungsten steel in the hardened condition has a higher residual induction than the other magnet steels. Tungsten steel requires water-quenching, while 3.5 chrome steel is oil-quenched. In addition, chrome steel is a somewhat lower cost material. For these reasons, in recent years it has been substituted to some extent in applications where tungsten steel was formerly used.

The best permanent magnet steel in commercial use is the 35% cobalt steel,[29] a complex alloy which contains, in addition to the cobalt, tungsten, chromium and carbon. Typical values of coercive force and residual induction for this material are 220 oersteds and 9500 gauss. Although this material is decidedly superior in properties to the other magnet steels, because of high cost, its use is limited to applications where space curtailment and apparatus requirements eliminate the cheaper steels.

New Developments in Permanent Magnet Alloys

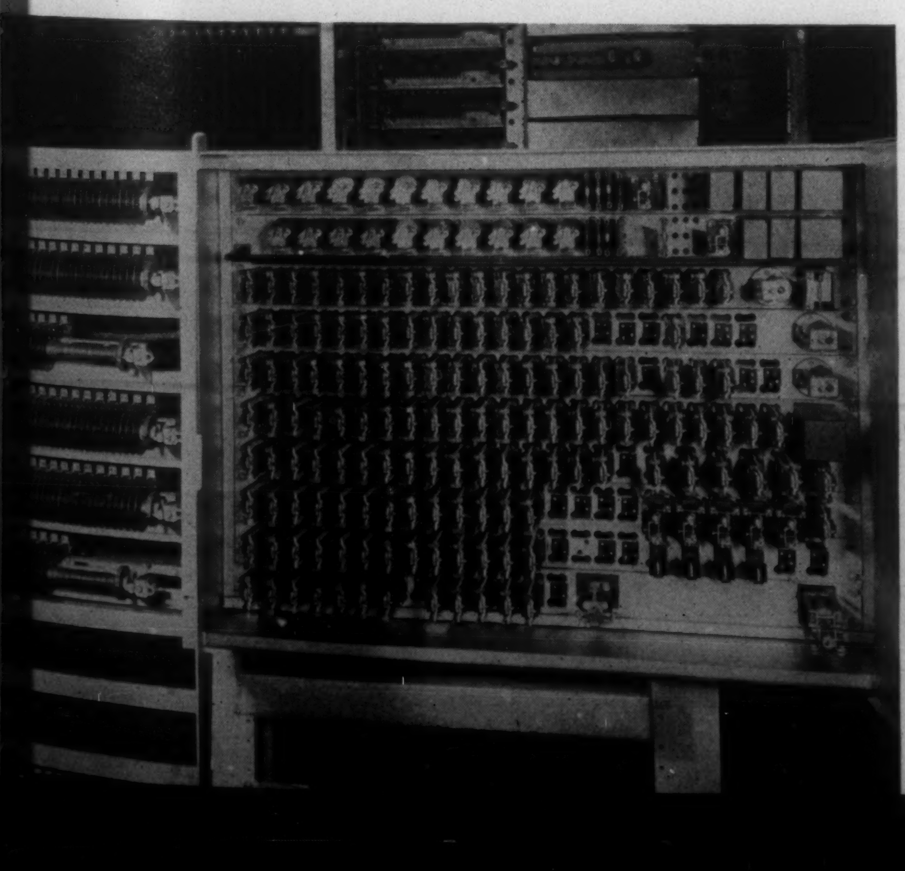
Within the last 5 years, there have been a number of publications[30, 31] describing new materials which have properties of interest to engineers using permanent magnets. These materials are alloys with no intentional carbon additions, and, hence, are a radical departure in this field. The new magnet alloys solidify as α-solid solutions which by suitable heat treatment at a lower temperature decompose precipitating second phases. Contrary to the case with the iron-carbon alloys, the α-solid solution undergoes no phase change with decreasing temperature. Consequently the alloys have a coarse grain while the hardened magnet steels have a fine grained structure due to the intermediate phase change.

The permanent magnet qualities, however, result from the same type of metallurgical reaction that occurs in the carbon steels, that is, a precipitation of a second phase which is dispersed throughout the α-solid solution. The useful properties are secured by the usual precipitation-hardening treatments; either a quench from a high temperature during which precipitation occurs, or a quench followed by an aging treatment at a lower temperature to produce the precipitation. Examples of alloys of this type are the iron-nickel-aluminum alloys, which have been described by Mishima,[29] and the iron-cobalt-molybdenum and iron-cobalt-tungsten alloys, which have been described by Seljesater and Rogers,[30] and Köster.[30]

Iron-Nickel-Aluminum Alloys

A representative composition of the alloys described by Mishima[30] consists of 65% iron, 25% nickel and 10% aluminum. The composition may be further modified by the addition of manganese, vanadium, cobalt, chromium, tungsten, molybdenum, or copper.

For the simple ternary alloy in the cast condition a coercive force of 240 oersteds and a residual induction of 9600 gauss have been reported by Mishima.[30] By slight modifications in compositions, coercive forces of over 500 oersteds in combination with re-



Several score R type relays as well as relays of other types are assembled in a panel sender—the "mechanical brain" of the dial telephone

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* A commendable detailed discussion of tungsten magnet steels is given by Gregg in the recent book, Alloys of Iron and Tungsten. McGraw Hill Book Company, 1934, page 212.

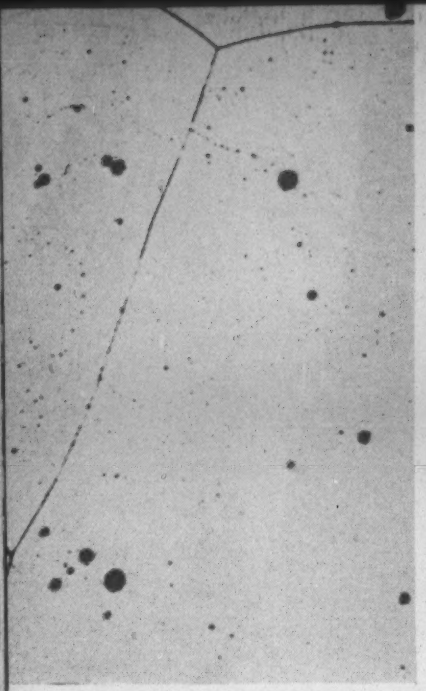


Fig. 14. Typical Structure of an Iron-Nickel-Aluminum Alloy, containing 25% Ni and 10% Al, after quenching from 1200° C. in oil. In this condition the alloy has its optimum permanent magnet quality. Mag. 125×

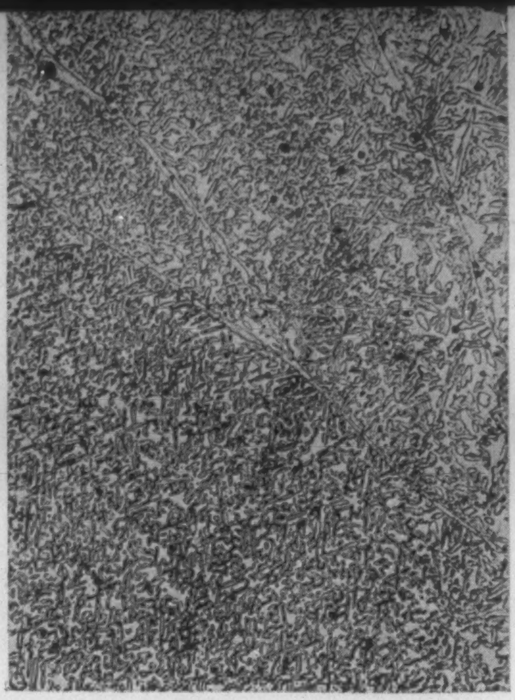


Fig. 15. Structure of the same alloy shown in Fig. 14 after a subsequent aging treatment of 24 hours at 1000° C. This treatment has resulted in the precipitation of a large amount of the second phase. Mag. 125×

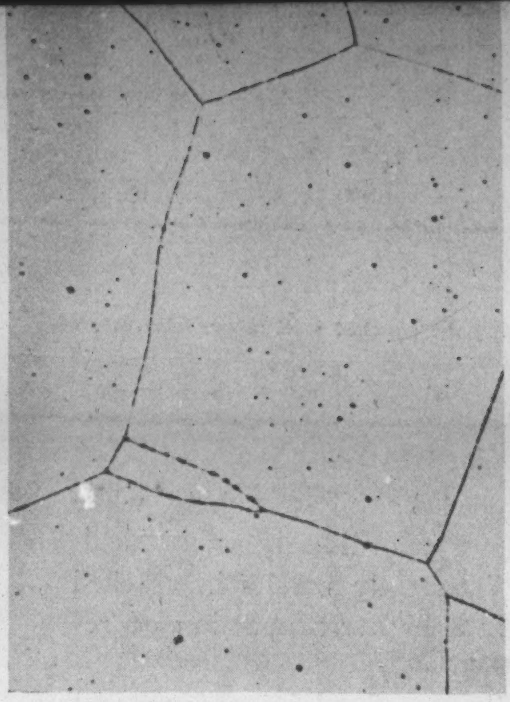


Fig. 16. Typical Structure of an Age-Hardening Iron-Cobalt-Molybdenum Alloy, containing 12% Co and 16% Mo, after quenching from 1300° C. Mag. 125×.

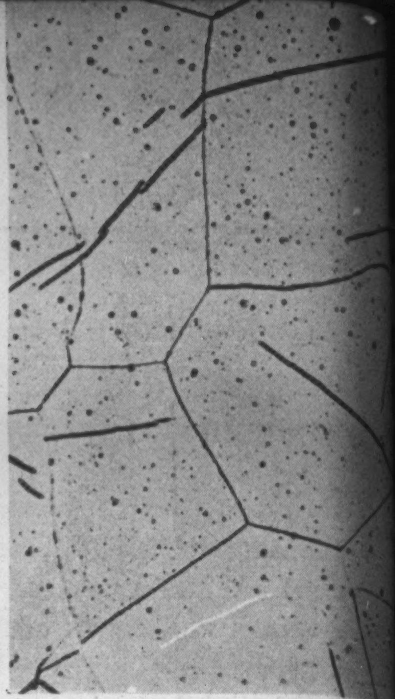


Fig. 17. The Same Alloy as shown in Fig. 16 after a subsequent aging treatment of 5 hours at 725° C. The precipitate is visible as rounded inclusions and as narrow bands. Mag. 125×

sidual inductions of approximately 9500 gauss are reported. Values for 3 Mishima alloys presumably of different composition have been reported recently by Steinhaus and Kussman[30] and are given below.

Type of Mishima Alloy	Coercive Force Oersteds	Residual Induction Gauss
MK1	660	7600
MK3	440	9800
MK5	130	10800

Köster[30] has investigated the ternary equilibrium conditions for the iron-nickel-aluminum alloys. In the range of compositions of interest for magnet purposes, a surface of solubility varying with the temperature exists. It would be expected, therefore, that these alloys would be amenable to age-hardening treatment. This has actually been demonstrated by Köster for the alloys of iron-nickel-aluminum. The curves shown in Fig. 18 are reproduced from his published data and will be recognized as demonstrating typical age-hardening phenomena. The optimum aging temperature appears to be 700° C.

The fact that Mishima obtained high permanent magnet quality in specimens in the cast condition can be explained in that the precipitation of the second phase occurs during the simple cooling of the casting. It would be expected, therefore, that the magnet properties obtained would depend upon the casting dimensions and the rate of cooling. If this is true, it might be desirable in some magnet structures to subsequently heat treat the material to obtain uniform and reproducible results.

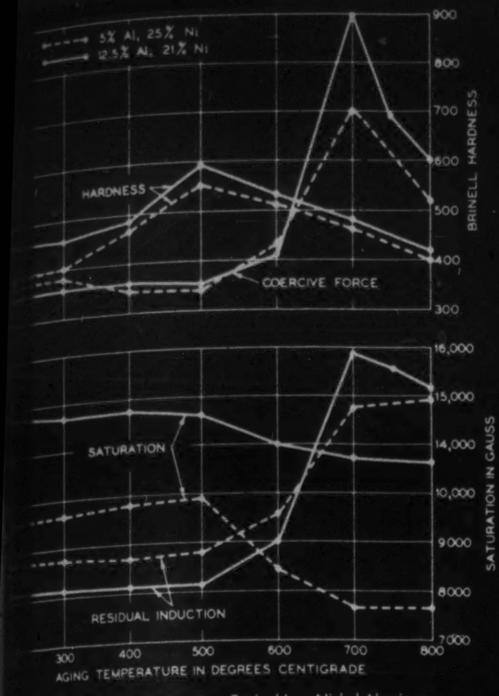
The fact that precipitation occurs is indicated more completely by examination of the photomicrographs in Figs. 14 and 15 of a typical iron-nickel-aluminum alloy after quenching, and after quenching followed by aging at 1000° C. for 24 hours. There is no visual evidence of the second phase in the quenched specimen although some precipitation of submicroscopic particles undoubtedly has occurred. In the aged specimen, in Fig. 15, the second phase appears unmistakably.

Iron-Cobalt-Molybdenum and Iron-Cobalt-Tungsten Alloys

The age-hardening characteristics of alloys in these systems were established some years ago by Sykes, who developed the alloys for tools. Later, Seljesater and Rogers[31] reported that these alloys possess permanent magnet characteristics. A detailed report on the magnet properties has been made by Köster.[31] Of the 2 systems, it appears that appreciably higher coercive forces are available in the one consisting of iron, cobalt and molybdenum. In Fig. 19 are shown the combinations of residual induction and coercive force obtained by Köster in the latter system with variations in molybdenum and cobalt content. Coercive forces of over 200 oersteds, associated with residual inductions of approximately 10,000 gauss, are given.

The desirable properties of this class of materials are developed by a double heat treatment which consists of a quench from a high temperature followed by aging at a lower temperature. The alloys are precipitation hardening in the same manner as the non-ferrous copper-beryllium alloys or lead-calcium cable sheath alloys. The heat treatment is illustrated in Fig. 20 which shows the effect of aging on the properties of an alloy containing 15% cobalt and 18% tungsten reproduced from Köster's published data. The alloy was initially quenched from a temperature of 1300° C., and subsequently aged at temperatures from 300° to 800° C. The best results are obtained by aging at temperatures between 700° and 800° C.

Telephone transformers with cores either of silicon steel, as the three in the rear row, or of permalloy, as the three in the triangular group at the right. The difference in size for comparable characteristics is quite evident



18. Effect of Aging Treatment on Typical Iron-Nickel-Aluminum Magnet Alloys — Köster.[31]

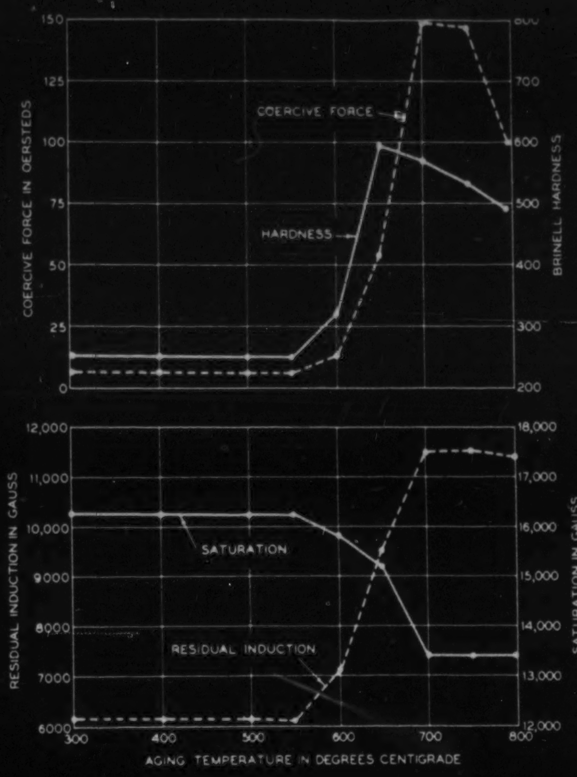
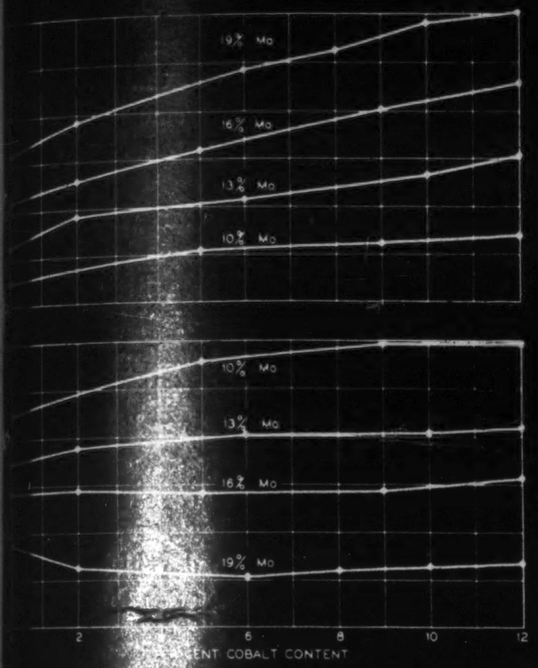


Fig. 20. Effect of Aging Treatment Showing Typical Age-Hardening Phenomena for an Iron-Cobalt-Tungsten Magnet Alloy — Köster.[31]



19. Effect of Different Combinations of Cobalt and Molybdenum on the Coercive Force and Residual Induction of Iron-Cobalt-Molybdenum Alloys in the Heat-Treated Condition. — Köster.[31]

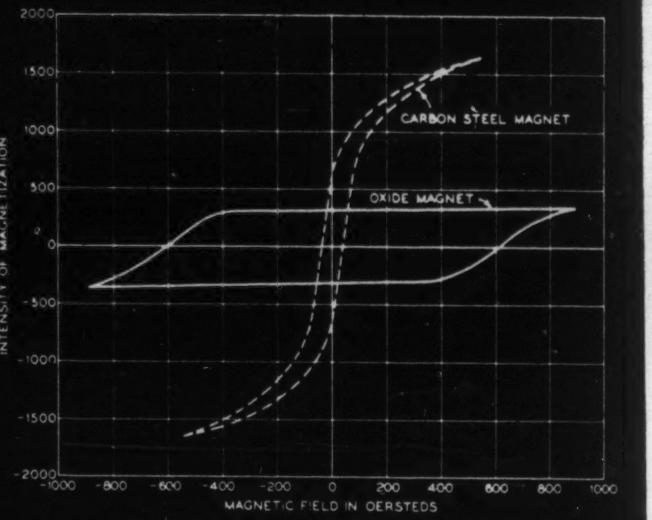


Fig. 21. Comparison of some Magnetic Characteristics of an Oxide Magnet with those of Carbon Steel — Kato and Tokei.[32]

The precipitation of the second phase in a typical iron-cobalt-molybdenum alloy is illustrated by a comparison of Figs. 16 and 17. The section in Fig. 16, which is for the alloy after quenching from 1300° C., shows a typical solid solution structure with a small number of rounded inclusions resulting either from the deoxidation of the melt or from incomplete solution at the high temperature. In Fig. 17, a section of the same alloy after quenching and subsequent aging, the precipitate is visible as rounded particles within the grains and as elongated, needle-like structures within and along grain boundaries.

Köster[31] reports that these alloys can be rolled or otherwise shaped at sufficiently high temperatures and can be readily stamped at red heat. The alloys machine readily in the quenched condition, but on account of the coarse grained structure and consequent brittleness, they must be machined without shock.

Oxide Magnets

In this class of materials are included the metallic oxide magnets recently described in the literature by Kato and Tokei.[32] The metallic oxide magnets open a new field of permanent magnet materials.

These magnets are composed, according to the Japanese authors, in one instance of a solid solution of cobalt ferrite ($CoFe_2O_4$) in magnetic iron oxide ($FeFe_2O_4$). Although the method of manufacture and exact compositions are not completely disclosed, it appears that the preparation involves the powdering of the metallic oxides, compressing in a suitable die to the desired shape and subsequent heating.

Cobalt ferrite magnets, it is reported, are not easily magnetized at room temperature, but if the temperature is raised, for example, to 300° C. the magnetization is readily accomplished. In this procedure the magnet is cooled in the magnetizing field. If the magnet has once been magnetized at the high temperature, succeeding magnetizations can be carried out at room temperature.

The magnetic characteristics of the material are illustrated in Fig. 21, in which a hysteresis loop for a metallic oxide magnet is compared with one for carbon steel. The coercive force of the new material is approximately 600 oersteds and the residual intensity of magnetization, 320 units, corresponding to a residual induction of approximately 4000 gauss.

The high coercive force of the oxide magnet makes possible the more exact location of poles and permits the utilization of the material in short magnets. Because of the lower density of the oxide compared with that of iron, the oxide magnets have approximately the same induction flux as metallic magnets on a weight basis.

The descriptions of the materials given here has been obtained from the Japanese publication.[32] So far as is known, no investigation of the preparation or of the properties of the material has been reported in this country.

Summary of New Permanent Magnet Materials

The properties of the new permanent magnet materials discussed are summarized in Table II.

Table II. The Properties of Some New Permanent Magnet Materials

Materials	H_c-Oersteds	B_r-Gauss	$H_c \times B_r \times 10^{-3}$
Iron-Cobalt-Molybdenum Alloys	50-300	12000-8500	600-2550
Iron-Cobalt-Tungsten Alloys	150	11500	1720
Iron-Nickel-Aluminum Alloys	130-660	10800-7600	1400-5000
Oxide Magnets	600	4000	2400

An important consideration in connection with the new materials is the broadening of the field of possible new magnet alloys. Previously it had been generally considered that the field of useful permanent magnet materials was confined to the plain and alloy steels. The new metallic materials are systems which are precipitation hardening, and suggest possibilities for developing useful alloys in other similar systems of iron.

(Continued from page A-19)

Skimming

NOBODY can read all the metallurgical literature of the day, nor can any producer or user of metals disregard it. Hence, there must be some means of separating what is, for each individual, the cream that fits his own needs from the skim-milk that does not. What is the thinnest of milk to one not concerned with a given subject may be the thickest of cream to one who is.

Therefore, abstracts designed to serve a large group of producers and users of metals must cover a field far wider than the interests of any single reader. The reading of abstracts is itself onerous because they have already been concentrated and each abstract that is of any interest at all needs to be read in toto. The problem then is to select the ones to read.

This can be done in several ways. One person who knows the sort of thing a given firm is interested in, can go over our Current Metallurgical Abstracts and make a red √ mark against those that come in that category before the copy circulates to the executives, production men, and engineers and research staff. Different marks can call the attention of different departments.

Many firms take a number of copies that go to different individuals or departments instead of merely one copy for the library and one for circulation.

Since the index spacings are marked on each page of abstracts, a sheet listing the important abstracts and definitely locating them by their page numbers and index marks can be distributed to all such readers. In this issue, for example, MA 40 L10 locates an abstract of interest to the executive, MA 4R1 one to the open-hearth Superintendent, MA 10R4 one the heat-treating foreman should see, MA 6R1, one the chief metallurgist should study and so on.

Another way is to clip the pertinent abstracts, paste them on a sheet, or on cards for filing, and circulate the sheet or cards.

Any such plan saves time for those concerned, but it leaves a problem for the one whose duty it is to select the abstracts important to a given group or for the individual reader. Of course, the classification of the abstracts helps, but so many articles could properly be classified under several headings that it is unsafe to assume that any abstract has no bearing on one's interests just because it does not appear under a certain classification. Skimming by reading titles and watching for key words in the text can be done at a very rapid rate if one trains himself to it. One can get so that a word or symbol that connotes something of supreme interest to him will simply "jump" out of the page to meet his eye.

Worthwhile suggestions as to how to acquire this valuable facility—useful not only in reading abstracts but in general technical reading—will be found in a little book by W. B. Pitkin (who is also the author of "Life Begins at 40") entitled, "The Art of Rapid Reading." Practice along the lines suggested in that book will enable one to run over a journal and tell without reading each article in full which ones he should glance at, and make note of for future reading if, as and when the subject becomes of importance; which ones he should read with moderate care for general information, and which ones he should pore over till he is as conversant with the subject as the author himself.—H. W. GILLETT

As METALS & ALLOYS goes to press, announcement is published of the sudden death from heart desease on Jan. 11, of **Dr. John A. Mathews**, vice president in charge of research, Crucible Steel Co. of America, and one of the Editorial Advisory Board of this journal. An extended obituary notice will appear in the February issue.

William Watts Macon, for twenty-three years connected with the editorial department of The Iron Age, successively as engineering editor, managing editor, editor-in-chief and consulting editor, died on January 1st, in New York, N. Y., of a cerebral hemorrhage. He was fifty-nine years old. Before becoming associated with The Iron Age, he was editor of the Engineering Record and the Metal Worker.

Mr. Macon was born in New York on May 19, 1875, and was graduated from Cornell University with the degree of mechanical engineer in 1898. He was a contributor to the "Encyclopedia Britannica" as well as to his own papers and to various trade and technical journals. During the World War he was a member of the group of American trade journalists which was conducted through Great Britain and France by the British Government.

During his college career he was secretary of his class and up to his death he was active in Cornell alumni affairs. He was a member of the American Society of Mechanical Engineers, the American Iron and Steel Institute and the Cornell Society of Engineers, of which he was at one time president. He also was a member of the Engineers and the Cornell Clubs of New York, and the Engineers Club of Brooklyn. He is survived by his wife, Maud A. Macon, and a daughter, Mrs. B. S. Cushman.

The plant of **Maurath, Inc.**, 7309 Union Avenue, Cleveland, Ohio, was damaged by fire on December 23d. According to the president, George A. Maurath, temporary ararngements have been made so that production has been resumed and the company will soon be in a position to continue to supply the usual demand for welding rods.

The New Jersey Zinc Sales Company, New York, N. Y., has now purchased from the estate of Ralph E. Potter, who was associated with them for many years, the business and good-will of David Randall & Company, and will continue this business in the name of The New Jersey Zinc Sales Company. Until further notice the company will operate from the same Boston address, (55 Kilby Street and through the same Boston warehouse, (the Albany Terminal Stores,) with which customers are already familiar as a result of dealings with Mr. Potter and David C. Randall & Company in connection with their products. George W. Harragan, who, starting the early part of 1934, assisted Mr. Potter while the latter was ill, will continue as New England representative, and carry on the tradition of good service established by David Randall & Company.

The first annual welding conference on electric and oxy-acetylene welding will be held at Texas Technological College, Lubbock, Texas, Feb. 14 and 15, 1935. All manufacturers and jobbers of welding equipment are invited to display and demonstrate their equipment All inquiries should be addressed to Prof. H. F. Godeke, professor of mechanical engineering, Lubbock, Texas.

ORE CONCENTRATION (1)

JOHN ATTWOOD, SECTION EDITOR

Crushing, Grinding & Plant Handling (1a)

Iron Ore Sintering in U.S.S.R. I. G. Mishkov. *Domez,* No. 7, 1934, pages 1-5. In Russian. Experiments conducted in 1932 at Kertch Works showed that the use of ore sinter reduced the fuel consumption 27% and increased the production 32% as compared with raw ore. A medium-size blast furnace was used for experiments. Many sintering plants are planned, mostly along Dwight-Lloyd lines but none is even partially completed as yet. (1a)

Flotation (1c)

The Effect of Depressing Agents on the Flotation of Pure Zinc Blende and Artificial Mixtures of Zinc Blende and Galena (Untersuchungen über den Einfluss drückender Reagenzien auf die Flotierbarkeit reiner Zinkblende und künstlicher Gemenge von Bleiglanz und Zinkblende). M. Winkler. *Metall und Erz,* Vol. 31, Aug. 1934, pages 358-362. The depressing effect of the reagents on the flotation of ZnS was determined on a laboratory scale under constant conditions. Some reagents have a permanent, others only a temporary effect. KCN and NaCN are effective depressors for ZnS and their effect is increased by the addition of $ZnSO_4$. By itself, $ZnSO_4$ has no retarding power. A differential flotation of ZnS and PbS was obtained with mixtures of cyanides and $ZnSO_4$, but not with the cyanides alone. The retarding effect of cyanides can be overcome by the addition of $CuSO_4$ or by replacement of the solution with distilled water. Na_2S has only a temporary retarding action and no selective power. Its effect can be overcome by strong oxidizing agents. Two commercial depressing agents, one containing $Na_2Zn(S_2O_4)_2$ and $(NH_4)_2Zn(S_2O_4)_2$, the other ZnS_xO_6, were found to be selective in mixtures of ZnS and PbS, yielding a pure Pb concentrate. Alkalies and alkaline earths have a temporary depressing effect. In retarding the flotation of PbS from mixtures of pure ZnS and PbS, $K_2Cr_2O_7$ was very effective, $KMnO_4$ only after 30 min., and Na_2HPO_4 not at all. The action of $KMnO_4$ was hastened by the addition of $Pb(NO_3)_2$, $ZnSO_4$, $ZnCl_2$, $CuSO_4$, $CuCl_2$ and $AgNO_3$. In practice some of these salts are always present. CEM (1c)

Action of Dilute Silver Solutions on Mineral Sulphides (Die Wirkung von vedünnten Silberlösungen auf mineralische Sulfide). S. A. Kamenezki. *Zeitschrift für anorganische und allgemeine Chemie,* Vol. 219, Sept. 29, 1934, pages 335-340. The action of dilute $AgNO_3$ was investigated on a large number of mineral sulphides. The reaction velocity of $AgNO_3$ on the sulphides parallels their comparative solubilities except in the case of Cu_2S. Tests were made to show the effect of surface and equations are given for determining the amount of silver precipitated in 10 minutes on 1 $cm.^2$ mineral surface. WB (1c)

Capillary-Electrical Phenomena and Wetting of Metals by Electrolytes. II. (Kapillarelektrische Erscheinungen und Benetzung von Metallen durch Elektrolyt-Lösungen II). A. Gorodetzkaja & B. Kabanow. *Physikalische Zeitschrift der Sowjetunion,* Vol. 5, 1934, No. 2, pages 418-432. Determination of the contact angle of Pt, Zn, Ag, Ga and Th-amalgams in electrolytes at different polarizations. Determination of the location of the maximum of the contact angle for Pt, platinized Hg, Ag, Ga, and Tl amalgams. EF (1c)

Amalgamation, Cyanidation & Leaching (1e)

Experimental Tests on Gold Ore from McKellar-Longworth Property, Schreiber, Ontario. C. S. Parsons, A. K. Anderson, J. D. Johnston & W. S. Jenkins. *Canadian Department of Mines, Mines Branch Report* No. 736, 1934, pages 35-39. A quartz ore containing 2.76 oz. Au/ton was treated. Amalgamation alone will recover more than 90% of the Au; concentration of amalgamation tailing will bring recovery up to 96% or more. Flotation alone was not satisfactory. AHE (1e)

Recovery of Gold from Black Sand Concentrate from Rock Creek Placer Deposits, British Columbia. C. S. Parsons, A. K. Anderson, J. D. Johnston & W. S. Jenkins. *Canadian Department of Mines, Mines Branch Report* 736, 1934, pages 143-144.—Barrel amalgamation recovers 99.9% of the Au from a sand containing 3.92 oz. Au/ton. AHE (1e)

The Recovery of Gold from Ore and Mill tailing of the Horseshoe Mines, Limited, Kenora, Ont. C. S. Parsons, A. K. Anderson, J. D. Johnston & W. S. Jenkins. *Canadian Department of Mines, Mines Branch Report* 736, 1934, pages 130-138.—Amalgamation recovered 60-68% of the Au. Cyanidation of the tailing increased overall recovery to 92-93%. Amalgamation followed by flotation of the reground tailing gave 94.5% recovery. Straight cyanidation of -200 mesh ore yielded 94.8% of the Au. AHE (1e)

The Electrometallurgy of Cadmium as Applied to Electrolytic Zinc Plant Purification Residues. Raymond M. Miller. *State College of Washington, School of Mines & Geology, Metallurgical Research Bureau,* Bulletin No. A, March 1934, 30 pages. Methods for recovery of Cd are reviewed, with particular emphasis on hydrometallurgy, including leaching, precipitation of Cd, re-solution, electrolysis, and melting. An improved leaching cycle was developed, as follows: (1) Leach in acid filtrate from (5). The most easily soluble oxides are dissolved and use up acid. (2) Add Zn dust in excess of amount to precipitate Cu; Cu, Cd and Zn are precipitated. (3) Filter; Cd is precipitated from the filtrate. (4) Leach the filter cake with H_2SO_4, to dissolve Cd and Zn and leave Cu. (5) Filter; Cd is precipitated from the filtrate. Advantages: Simplicity, Cu-free Cd-Zn solution; high extraction and short leach period (1 hr. max.). 14 references. AHE (1e)

Trends and Opportunities in Gold-Ore Treatment. A. W. Allen. *Mining Congress Journal,* Vol. 20, Sept. 1934, pages 29 and 42. Adoption of flotation of gold ores has increased the scope of application of the older processes, amalgamation and cyanidation. Extremely low-grade materials are now susceptible to profitable exploitation. Cyanidation remains the most satisfactory method for treating the concentrates. The volatilization process has obvious merits; extraction is high but recovery low. Research is needed to determine possibilities of using charcoal for precipitation of gold from cyanide solutions. BHS (1e)

A New Process for Oxygenating Solutions. T. K. Prentice. *Journal of the Chemical, Metallurgical and Mining Society of South Africa,* Vol. 34, May 1934, pages 385-387. Discussion. See *Metals & Alloys,* Vol. 5, Sept. 1934, page MA 429. AHE (1e)

Treatment of Refractory Tailings. W. L. Tucker. *Chemical Engineering & Mining Review,* Vol. 26, Aug. 5, 1934, page 421. Experimental results of cyaniding refractory tailings from the New Deloraine Gold mine at Deloraine, South Australia, show a 10% extraction with a cyanide consumption of 2 lbs./ton. With addition of bromocyanide and giving extended contact, extraction rose to 50%. Slime, without addition of bromocyanide, gives extractions up to 85% with cyanide consumption of 5-6 lbs./ton. of ore. WHB (1e)

ORE REDUCTION (2)

A. H. EMERY, SECTION EDITOR

Non-Ferrous (2a)

Preparation and Properties of Copper Ferrite. F. S. Wartman & A. J. Thompson. *Progress Reports—Metallurgical Division. 3. Studies in the Metallurgy of Copper. United States Bureau of Mines, Report of Investigations No.* 3228, May 1934, pages 15-21. The finer the grains in the mixture of Fe and Cu oxides the more rapid the formation of ferrite. Heating 1 hour at 110° gave 3-5% ferrite; 650°, 67%; 700° 84%; 800°, 95.5%; 900° 97% and 1000°, 96.3%. Most of the ferrite formed by heating at a particular temperature was formed during the first few hours. Excess of either oxide tended to produce more rapid formation. Quenching in H_2O after heating at 900° or 1000° gave a magnetic product. X-ray diffraction patterns are almost identical with those for magnetite and indicate a cubic crystallization with the length of the unit 8.40 Angstroms. Material slowly cooled or annealed at 350° had a diffraction pattern indicating tetragonal crystallization with a unit cell of the dimensions $a = 8.28$ and $c = 8.68$. Cuprous ferrite crystallized to give hexagonal symmetry. The parameters of the unit cell were $a = 6.06$ and $c = 2.82$. Magnetic permeability on a spring balance on which Mineville magnetite gave a reading of 240 was 260 for cubic cupric ferrite, 60 for the tetragonal cupric ferrite and 4 for cuprous ferrite. Cupric ferrite, is soluble in 10 and 20% H_2SO_4 (1 hour), 10% HCl (30 hours) and concentrated HCl (5 hours) at 95°; -350 mesh, is soluble in 5% H_2SO_4 or stronger (1 hour), concentrated HNO_3 (1 hour), 10% HCl (1 hour) and concentrated HCl (3 minutes) at 95°. Cuprous ferrite, -350 mesh, is soluble in 5% H_2SO_4 or stronger (1 hour) at 95°. AHE (2a)

Sintering Practice at Anyox. T. W. Cavers. *Transactions Canadian Institute Mining and Metallurgy,* 1934 (*in Canadian Mining and Metallurgical Bulletin No.* 269, Sept. 1934) pages 437-441. An average charge consists of concentrate (chalcopyrite, pyrrhotite, a little pyrite and a minor amount of gangue) 72%, flue dust from blast furnace 7%, lime rock 4%, converter slag 3%, and siliceous ore 14%. The charge and sinter analyze, respectively: Cu 13, 14.5; SiO_2 20, 23; Fe 29,33; CaO 5,5; S 24,13; Al_2O_3 3,3 and MgO 1,1%. AHE (2a)

Smelting, Casting and Rolling of Electrolytic Copper. Roy H. Miller & W. S. Adams. *Wire & Wire Products,* Vol. 9, Sept. 1934, pages 322-329, 349-351. Present day practices in melting, casting, rolling, equipment and lay-out of plants are described. Ha (2a)

Metal Losses in Smelting Plants and their Avoidance (Die Metallverluste der Hüttenwerke und ihre Vermeidung). V. Tafel with appendix by H. Porzig. *Metall und Erz,* Vol. 31, Feb. 1934, pages 49-59. Includes discussion. A lecture discussing losses through pulverization, storage, transportation, volatilization leaching solutions and valuable impurities (such as Ag) in Pb and slags. The loss of Ag through volatilization when heated for 1 hour at 1400°C. was 17% in CO, 23% in CO_2, 30% in N, 42% in air and 46% in O. The loss of Ag_2O, Ag_2SO_4 and Ag_2S was higher than the loss of Ag. The addition of PbO to Ag reduces volatilization, SiO_2 increases it, and CaO has little effect. CEM (2a)

Smelting in the Lead Blast Furnace — Handling Zinciferous Charges. G. L. Oldright & Virgil Miller. *Progress Reports — Metallurgical Division. 7. Studies in Lead Metallurgy. United States Bureau of Mines, Report of Investigations No.* 3242, Sept. 1934, 11 pages. A long sintering machine produces more sinter and requires less space per ton of sinter, uses less oil and has a lower cost of upkeep than a short one. With a machine fed a deep bed (11 in.), a larger proportion of more difficult fusible, sloppy material, such as Zn-plant residues, may be used. A short machine gives a somewhat better fused cake. Where a very rich, fusible Pb concentrate is to be sintered, it is best to use a thin bed and short machine. The Trail sinter analyzes Pb 48.0, Zn 8.8, Fe 13.3, SiO_2 7.5, CaO 4.1 and S 1.5%; it forms more than 80% of the charge to the blast furnaces; 10% coke is added in the feed. The gases at the top of the Trail furnaces contain more free O and less CO than corresponding gases elsewhere; an average analysis was CO_2 11.2, O_2 7.9, and CO 4.5%. The gases at the tuyères contain more CO_2, less CO and more N than corresponding gases sampled at other plants; CO is seldom over 30%, usually less than 10%; CO_2 is 0-30%, usually less than 10%; the average of all samples is CO_2 10.5, O_2 3.9, CO 13.8 and N 71.8%. The rate of descent of the stock column is fairly uniform (1½ in./min.). The operating conditions fluctuate less when the atmosphere is less reducing, the charge consists mostly of hard sinter and there is more Pb in the slag. Fluctuations of temperature in the shaft of a blast furnace are the main cause of accretions. Accretions at Trail are richest in Zn and S at the lowest elevations; there is more ZnS next to the wall and more slag-forming constituents close to the charge. Accretions near the slag tap keep away the coke and make the slags leaving the furnace colder and richer in Pb. More accretions are made where there is more coke and S in the charge. A system of baffles to insure uniform distribution of feed increased smelting rate 12.4—36.6%. Slag averaged Zn 18.0, Pb 4.35, SiO_2 18.7, Fe 28.9, CaO 7.8, Al_2O_3 3.7, MgO 1.2, Mn 0.99, Cu 0.19, and S 1.4%. About 9% of the total slag was in the form of spinels. Slags containing less than 18% SiO_2 are richer in Pb; the most acidic slag contains the smallest percentage of Pb as metal. Pb content of slags rich in metallic Pb can be decreased by adding SiO_2. If Pb is oxidized, add coke. As the furnace smelts faster, Pb content of slag increases. AHE (2a)

The Trail Heavy-Chemical Plants. R. W. Diamond. *Transactions Canadian Institute of Mining and Metallurgy,* 1934 (*in Canadian Mining & Metallurgy Bulletin* No. 259, Sept. 1934) pages 442-460. A gas averaging 5.9% SO_2 from the burning of Zn concentrate in suspension is used to make H_2SO_4, which is used in turn for manufacture of H_3PO_4. AHE (2a)

Metallurgy in Sweden. *Chemical Trade Journal & Chemical Engineer,* Vol. 93, Nov. 10, 1933, page 338. Abstract of paper by Sven Brohult presented at a meeting of the Chemical Society in Upsala, Sweden. The recovery of the separate constituents in the complex Boliden ore containing Au, Ag, Cu and As is described. JN (2a)

The Aluminum Industry. George Boex. *Chemical Trade Journal & Chemical Engineer,* Vol. 92, June 9, 1933, pages 455-456. Abstract of a paper read before the Institution of Mechanical Engineers in Edinburgh, May 30, 1933, on the production of Al from bauxite ores at the various plants of the British Aluminium Co. See *Metals & Alloys,* Vol. 5, July 1934, page MA 373. JN (2a)

Lead. *Chemical Trade Journal & Chemical Engineer,* Vol. 93, Aug. 4, 1933, page 78. Abstract of the chapters on metallurgy and concentration of Pb in New South Wales as given in a monograph on "Lead" published by the Imperial Institute. See *Metals & Alloys,* Vol. 5, Mar. 1934, page MA 77. JN (2a)

Zinc Industry Developments. *Chemical Trade Journal & Chemical Engineer,* Vol. 93, Nov. 24, 1933, page 377. Report on speech by Sir Robert Horne, M.P., chairman of Imperial Smelting Corp., Ltd. The use of 16 vertical retorts for the distillation of Zn has replaced nearly 2000 horizontal retorts and produces Zn of over 99.99% purity. New processes and developments for the production of ZnS, lithopone, ZnO, Ti pigments, and $Al_2(SO_4)_3$ are discussed. JN (2a)

Reaction of Alumina and Carbon in the Arc (Über die Reaktion der Tonerde mit Kohle im Flammbogen). W. D. Treadwell & J. Hartnagel. *Helvetia Chimica Acta,* Vol. 27, Oct. 1, 1934, pages 1384-1389. Experiments were carried out on the reduction of Al_2O_3 mixed with charcoal in a laboratory arc furnace. Some melts contained additions of quartz and Fe oxide to form respectively a 30/70 Si-Al alloy and Al_3Fe. Most of the Al evaporated and formed Al-carbide and oxide by secondary reactions. Al vapor forms Al_4C_3 at a much faster rate in CO than in contact with solid C. The presence of CO radically cuts down the Al yield. This effect is less pronounced in the presence of SiO_2 and Fe_2O_3. The percentage of Al_4C_3 formed varied between 0.25 and 61%. EF (2a)

Formation Energy of Magnesium Oxide and Its Reduction with Carbon (Die Bildungsenergie des Magnesiumoxyds und seine Reduktion mit Kohle). W. D. Treadwell & J. Hartnagel. *Helvetia Chimica Acta,* Vol. 27, Oct. 1, 1934, pages 1372-1384. The free formation energy of MgO, free energy of its reduction with C and the equilibrium constants are evaluated. Reduction tests were made with C in an arc and the reaction products were analysed. Reduction of MgO takes place readily. However, in spite of pronounced cooling, 4/5 of the metallic Mg is re-oxidized by CO in the reaction gases. Oxides of Si and Fe in the charge reduced by 1/3 the quantity of Mg subliming on the furnace walls. Formation of carbides (0-1.2%) is negligible. In a furnace atmosphere of CO, 2.9% MgC_2 was found and the Mg yield dropped from 26-30% to 13%. The presence of Fe_2O_3 and SiO_2 reduced the Mg yield to 9.1 and 6.7%, respectively. EF (2a)

Electrolytic Separation of Zinc from Roasted Zinc Blende in Ammoniacal Ammonium Sulphate Solution (Die elektrolytische Gewinnung des Zinks aus gerösteter Zinkblende mit ammoniakalischer Ammonsulfatlösung). G. Grube & J. G. Grunenfelder. *Zeitschrift für Elektrochemie,* Vol. 40, Oct. 1934, pages 677-685. Zn ferrite in roasted blende is difficultly soluble in H_2SO_4 and SiO_2 from the decomposition of Zn silicate interferes with filtration. Tests were made on the use of $(NH_4)_2 SO_4$. $ZnO + 2NH_4OH + (NH_4)_2SO_4 \longrightarrow Zn(NH_3)_4SO_4 + 3H_2O$. The NH_3 content of the solution was held at the upper limit of 150 g./l. which corresponds to a Zn content of 153 g./l. The total ZnO was dissolved in one hour at 25° C. The solution was electrolyzed at 0.05 to 0.03 amps./cm.^{2} of cathode with sheet Al cathode and passivated 18-8 anode at a current efficiency of 82-90% with 3.0-3.4 volts. Current density-potential measurements for cathode and equilibrium potential of $Zn/Zn(NH_3)_4SO_4$ with excess NH_4OH and $(NH_4)_2SO_4$ showed great stability of Zn complex ion and better conductivity with free $NH_4OH + (NH_4)_2SO_4$. Leach solution made with 2 mols NH_4OH to 1 mol $(NH_4)_2SO_4$ and 25% excess over that required to dissolve ZnO were added to roasted blende with 60.38% Zn. Zn silicate is not decomposed: therefore SiO_2 does not interfere in filtration. Curves are shown for ZnO leached versus time and temperature for two concentrations of solution. A double leach removes 91% of Zn. The solution is treated with Zn dust to remove Cu, Cd, Mn and Fe. A 99.95% Zn deposit is obtained at 89.9% current efficiency, voltage 3.45, current density 0.034 amps./cm.^{2} and temperature of electrolysis 29° C. WB (2a)

Heat of Formation of Cadmium Oxide, Cadmium Hydroxide and Zinc Oxide (Über die Bildungswärme von Cadmiumoxyd, Cadmiumhydroxyd und Zinkoxyd). G. Becker & W. A. Roth. *Zeitschrift für physikalische Chemie,* Abt. A, Vol. 167, Dec. 1933, pages 1-15. A new method of burning metals completely in the calorimetric bomb is introduced, checked on ZnO and applied to Cd. Heat of formation of CdO was 62.2 ± 0.2 kcal. and of $Cd(OH)_2$ 133.41 kcal. at 20° C. and constant pressure. EF (2a)

Effect of Roasting Conditions on the Gold Recovery of Reichenstein Arsenic Ores (Über den Einfluss der Röstbedingungen auf das Goldausbringen der Reichensteiner Arsenerze). J. Fischer & V. Tafel. *Metall und Erz,* Vol. 31, Sept. 1934, pages 393-395. Au was volatilized by incorrect temperature and air proportions during roasting of the As ores. At high temperatures, the Au recovery was higher the less air was used. In practice the air should be throttled and the roasting time be as long as possible. Towards the end the temperature can be raised almost to the m.p. CEM (2a)

Production of Ductile Tantalum by the Process of Growing in a Current of Hydrogen (Die Herstellung von duktilem Tantal nach dem Aufwachsverfahren in strömendem Wasserstoff). K. Moers. *Metallwirtschaft,* Vol. 13, Sept. 14, 1934, pages 640-643. Metallic Ta was made by thermal decomposition of $TaCl_5$ in a current of H and deposition on a W wire heated to 1200°-1450° C. Ta made in this way has excellent ductility and can be drawn into wire and sheet. Wires up to 3.5 mm. diameter can be made; a 2 mm. diameter wire can be produced in 15 min. The Ta does not absorb H, which would make it brittle, because it is in the unworked state while in contact with H, and the temperature of deposition is below that at which embrittlement in this state takes place. Ta which has been worked absorbs H at lower temperatures. The metal made by this process has a lower gas content than the usual drawn Ta wire. Nb also can be made from $NbCl_5$ by the same process, but it is not as ductile as Ta. CEM (2a)

Investigation of the Activation of Metals. Part 3 (Untersuchungen über die Aktivierung der Metalle 3). Rudolf Schenck & Fritz Kurzen. *Zeitschrift für anorganische und allgemeine Chemie,* Vol. 220, Oct. 8, 1934, pages 97-106. Tests were made on activation of Pd reduced from PdO precipitated on SiO_2 gel and clay. Nobility of PdO under various conditions of temperature and pressure was due to adsorption of O_2. WB (2a)

Investigation of the Condition of Sodium Dissolved in Molten NaOH (Über den Zustand des in NaOH-Schmelzen Gelösten Natriums). F. Halla & H. Tompa. *Zeitschrift für anorganische und allgemeine Chemie,* Sept. 29, 1934, Vol. 219, pages 321-331. In the electrolytic process for producing Na from molten NaOH the Na dissolves in the melt. Na starts to dissolve rapidly at 355° C. and increases in solubility up to 450° C. then decreases to about ¼ of maximum at 800° C. Tests showed depression of freezing point of NaOH with Na additions thus proving true solubility. The presence of Na_2O and NaH was determined by means of X-ray and chemical tests. The equation for the reaction is given by $2Na + Na + OH = Na_2O + NaH$. Cooling curve data are used to determine the melting point of pure NaOH by extrapolation as 327.6 ± .9° C. A formula is given showing the dependence of the melting point on the Na_2CO_3 and H_2O content of NaOH. WB (2a)

Calculation of Charge in Copper Matte Smelting. C. K. Avetissian. *Tzvetnuie Metallui,* No. 5, June 1933, pages 57-65. In Russian. After critically reviewing existing methods of calculating charges for smelting Cu matte, the author concludes that the best is that of Mostovich. No method takes into consideration the presence of oxides of Fe in the matte which introduces an error of 2 to 7%. The actual amount of S in the matte therefore is less than the theoretical amount. Using this difference, the author calculates the O in the matte, which then is taken into account in calculating the charge. In the discussion, it was pointed out that since both CuS and Cu_2S may be present in variable proportions in the matte it is impossible to determine the author's "theoretical amount of S" and consequently the amount of O, and that the error introduced by this method of calculation is within the limit of error due to neglecting the oxides of Fe in the method proposed by Mostovich. BND (2a)

Ferrous (2b)

The Interaction of Gases and Ore in the Blast Furnace. *Engineering,* Vol. 137, June 8, 1934, page 662. Outline of the recent paper presented before the Iron and Steel Institute, May 1934, comprising Parts III and IV of an experimental inquiry undertaken several years ago in the Imperial College of Science and Technology, London. The recent contributions are: "Proposed Methods for Comparative Testing of Iron Ores" by Prof. Bone, H. L. Saunders & N. Calvert and "Equilibria and Velocities in Ore Reduction" by Prof. Bone, H. L. Saunders & J. E. Rushbrooke. LFM (2b)

Conditions Inside a Blast Furnace. R. C. Tucker. *Iron & Steel Industry,* Vol. 7, Feb. 1934, pages 165-171. Paper read at meeting of Sheffield Metallurgical Association, Oct. 1933. Conditions vary widely from furnace to furnace and in some furnaces from time to time. From tuyères to center of hearth, coke is burned to CO_2 which is reduced to CO. The formation of cyanides also gives carbon monoxide. The combined water in $Fe(OH)_3$ is evolved as steam between 700 and 800° C.; this is decomposed yielding H_2 and CO. Hearth heat governs the blast furnace economy. CEJ (2b)

First Report of the Blast-furnace Practice Sub-committee. *Iron & Steel Institute,* Special Report No. 6, May 1934, 27 pages; *Iron & Steel Industry,* Vol. 7, June 1934, pages 295-297 (abstract). A detailed description of British blast-furnaces and practices was obtained with the aid of a questionnaire. Answers are summarized and discussed. Practices with foundry Fe, basic Fe, and hematite Fe are considered. Subjects discussed are raw materials, coke, furnace lines, maintenance of furnace lines, bell design, gas offtakes, tuyères and blast penetration, blowing, stove practice, charging, pig Fe quality, slag, and gas cleaning. An appendix by M. A. Vernon briefly discusses resistance of the blast-furnace burden to flow of gases. JLG + CEJ (2b)

Blast-furnace Linings. Part I.—An Examination of the Information Received in Reply to a Questionnaire Circulated to Iron Manufacturers. A. T. Green. **Part II.—Some Properties of the Fireclay Products used for Blast-Furnace linings.** A. T. Green, W. Hugill, F. H. Clews & H. Ellerton. *Iron & Steel Institute, Special Report* No. 7, May 1934, 56 pages; *Iron & Steel Industry,* Vol. 7, June 1934, page 298 (abstract); *Engineering,* Vol. 137, June 8, 1934, page 664 (abstract). Most refractories are obtained from sources near the furnace. Both hand-molded and machine-molded refractories are used. Drawings are given to show measurements of furnace linings after blowing out; the influence of lining materials and furnace design on the shape of a worn interior are discussed. Testing methods for refractories are described and tests on fireclay products reported. Tests include those for texture, chemical composition, refractoriness, refractoriness under load, porosity, after-contraction or expansion at 1350 and 1400° C. permeability to gases, and disintegrating action of CO. "Iron spots" tend to cause disintegration, but discoloration is not a sign of tendency towards disintegration. The higher the maturing temperature the better is the resistance to disintegration. 23 references. JLG + CEJ + LFM (2b)

Principles of the Design of Blast Furnace Lines. Jindrich Sarek. *Engineering,* Vol. 138, Aug. 31, 1934, pages 236-238; Sept. 7, 1934, pages 261-263. From paper read before the Iron & Steel Institute, May 1934. See *Metals & Alloys,* Vol. 5, Sept. 1934, page MA 430. LFM (2b)

Centralised Remote-control and Regulation in a Modern German Blast Furnace Plant. René W. P. Leonhardt. *Iron & Steel Industry,* Vol. 7, Feb. 1934, pages 159-164. A description of a blast furnace control plant. All regulating and switching operations of the pig Fe producing process have been automatised and all measuring values required for judging the operation of a blast furnace plant have been centralised at 1 point. CEJ (2b)

Production and Properties of Foamy Blast Furnace Slag (Gewinnung und Eigenschaften von Hochofenschaumschlacke). A. Guttmann. *Stahl und Eisen,* Vol. 54, Sept. 6, 1934, pages 921-927. Various water quenching methods for obtaining a porous foamy slag instead of a granular one are described. Very hot slags foam better. Compositions of several foamed slags are given varying in density from 0.28 to 0.65. The slag makes a very useful light weight, heat insulating, and refractory building material. SE (2b)

Pig-Casting Machine at the Works of Messrs. Ford Motor Company, Limited, Dagenham. *Engineering,* Vol. 138, Aug. 24, 1934, pages 189-190. Description of the general arrangement, the pouring end of the machine, and the construction of the mold belts. Cooling is carried out rapidly, yet a very satisfactory metal is produced. The pigs are uniform in size and no sow is attached to them as with the open-sand method. LFM (2b)

New Methods in Iron Production from Sponge Iron (Neue Verfahren in der Eisengewinnung durch Eisenschwamm). *Montanistische Rundschau,* (Section *Stahlbau-Technik*) Vol. 26, Oct. 16, 1934, page 6. After two years' successful operation of the Erwin process for the production of sponge Fe in a 40-ton pilot plant at Bochum, Germany, a new steel plant will be built at Kristianssand, Norway. In the Erwin process, which utilizes the low-grade Norwegian Fe ores, it has been possible to make a 95% sponge Fe by reduction and concentration of ores with as low as 35% Fe. The resulting product is very pure and has been found to be an excellent raw material in the production of alloy steel. BHS (2b)

The Krupp Direct-Iron Process (Das Krupp-Rennverfahren). F. Johannsen. *Stahl und Eisen,* Vol. 54, Sept. 20, 1934, pages 969-978. Ore mixed with cheap fuel such as coke breeze or powdered coal is charged into 1 end of a large slightly inclined revolving tube furnace and reduced directly to an Fe-C alloy containing 0.5-1.5% C. The maximum temperature at the exit end of the furnace is 1250° C. The Fe-C alloy is removed in the form of pasty blooms from which the slag is immediately squeezed out. The P in the ore remains in the blooms; most of the Mn is oxidized and goes to the slag; the S content of the blooms may vary with the basicity of the slag and ranges from 0.02 to 1.1%. Blooms from low-grade ore, especially that high in SiO_2 are best remelted in the blast furnace, but the better material may be charged into the open-hearth or electric furnace. The process showed favorable cost records and should be advantageous for localities with good ore but without blast furnaces or good blast furnace coke. SE (2b)

Petrographic Methods in Slag Examination. R. Graham & R. Hay. *Iron & Coal Trades Review,* Vol. 128, May 4, 1934, page 721. See *Metals & Alloys,* Vol. 5, Oct. 1934, page MA 471. Ha (2b)

Testing Briquettes Made According to Professor Averkijev. Shapovalov. *Domez,* No. 5-6, 1933, pages 30-34. In Russian. Briquettes made of ore fines and flue dust using water glass as binder had crushing strength of 42-173 kg/cm^2, good penetrability to gas and a greater porosity than average ores. Fire brick resistance to fluxing by ore (Hartmann method) was 96, to fluxing by these briquettes 80 to 86.8 (2b)

MELTING, REFINING & CASTING (3)

Molding Equipment for a Wormgear Z=22, t=5π, with Cast Teeth for a Triple, Right-hand Worm Formeinrichtung für eine Schneckenrad Z22, t=5π, mit gegossenen Zähnen für eine Schnecke, dreigängig, rechts). *Die Giesserei,* Vol. 21, June 8, 1934, pages 246-248. A simple molding arrangement is described which produces a gear to replace triple gears requiring costly machining operations. Ha (3)

Core Drying Facts. B. H. M. Lane. *Industrial Heating,* Oct. 1934, pages 75-76, 84. The different binders used in core making and methods for drying are discussed. Ha (3)

The Casting Skin (Die Gusshaut). E. Diepschlag. *Die Giesserei,* Vol. 21, Sept. 28, 1934, pages 408-412. Investigations into character, dependence on molding and casting conditions, and influence on testing results of the skin of castings are reviewed. All results indicate that wide chemical changes occur in the outer skin of cast Fe which may be traced to casting conditions. Tensile bending strength and hardness of a test piece vary considerably whether or not the skin is removed in the test, and also with the thickness of the cast piece from which the specimen is prepared. Specimens cast in blackened molds generally give a smoother and more uniform surface than those cast in non-blackened molds. 16 references. Ha (3)

A New Method for The Determination of Water Content and Distribution of Grain Size in Foundry Sands, Raw, Molding and Core Sands (Eine neuartige Methode zur Bestimmung des Wassergehalts und der Korngrössen-Mengenanteile von Giessereisanden, Roh-, Form- und Kernsanden). P. Bergmann, W. Claus & E. Waldschmidt. *Die Giesserei,* Vol. 21, Aug. 17, 1934, pages 350-352. The change of dielectric constant by the humidity content of a dielectric material is used for determining the H_2O content of the sand by comparison with an absolutely dry sand in a condensor. It is shown that by applying Stokes' law the distribution of grain (frequency of a certain grain size) in a sample can be determined by the sedimentation velocity of the sand. The instrument is described and the method illustrated by an example. Ha (3)

Faults of Construction and Pattern Technique that Make Difficult Molding (Konstruktive und modelltechnische Fehler, die dem Former die Arbeit erschweren). R. Löwer. *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, Sept. 16, 1934, pages 393-395. Discusses a number of instances to show how simplified construction facilitates molding work. GN (3)

Cycle of Molding Sand in Foundries (Der Kreislauf des Formsandes in Giessereien). A. Rodehüser. *Die Giesserei,* Vol. 21, Oct. 12, 1934, pages 425-426. Economy in the use of molding sand, its preparation, recovery from castings, and cleaning is discussed. Ha (3)

Properties of Molding Sands, Their Testing and Classification (Les Propriétés des Sables de Moulage, leur Essai, leur Classification). J. Lebruly. *Revue de Fonderie Moderne,* Vol. 28, Sept. 10, 1934, pages 261-265. Testing methods and apparatus, and English and American standards for classification are reviewed. Classifications according to grain size and clay content of sands are given and a table showing which types of sand should be used for thin, medium and thick castings of bronze and brass, Al alloys, gray iron, malleable iron and steel. Ha (3)

Non-Ferrous (3a)

G. L. CRAIG, SECTION EDITOR

Methods of Melting Aluminum Alloys (Verfahren zum Schmelzen von Aluminiumlegierungen). E. T. Richards. *Die Metallbörse,* Vol. 24, July 7, 1934, pages 857-859; July 14, 1934, pages 889-890; July 21, 1934, page 923. Discusses the melting of Al-Cu, Al-Cu-Fe, Al-Cu-Mn, Al-Fe, Al-Mn, Al-Ni and Al-Si alloys using as addition-alloys: (1) The commercial Cu-Al alloys with 33%, 40% and 50% Cu. Addition of deoxidized molten Cu to liquid Al is recommended since otherwise the melting temperature rises abruptly by 250°C. However some foundries utilize this exo-thermic reaction by melting in about 4/5 of the Al. The Al oxide formed by the deoxidation of the added Cu is removed by .2% Cu-P. American practice prefers addition of solid Cu as thin sheets, wire, etc., to the Al melt. Al is strongly overheated and a reducing or neutral atmosphere and protective covers (85 NaCl + 15 cryolite, or 1 borax + 2 cryolite) must be used. (2) 70-20-10 (m.p. = 865°C.) and 62.5-25-12.5 Al-Cu-Fe alloys are widely utilized. Author warns against adding solid Fe to Al-Cu melts. Cu + Fe should be added in the liquid state to molten Al. (3) 80-20-10 Al-Cu-Mn alloys are made in the same manner as (2) 2 pts. of Cu and 1 part Mn are close to the eutectic, melting at 868°C. Cu is melted first under borax. At 1150° red glowing lumps of Mn are added. The melt temperature is lowered to $\sim$925°C. and Cu-Mn is poured into the liquid Al. (4) A 10-90 Fe-Al alloy melts at 865° and quickly dissolves in Al at 750°C. Sheet Fe is directly dipped into Al at 900° for making the initial alloy. At 900° the oxidation losses are not much greater than at lower temperatures due to the reduced melting time. (5) Al-Mn alloys usually contain 20 or 25% Mn. Considerable oxidation losses are met with when pouring Mn into Al. In spite of slow melting progress, solid Mn must be added to overheated Al (900°) under a heavy protective cover. Al-Mn alloys disintegrate in air. Impurities accentuate this process and casting into thin plates counteracts it. A 50/50 Al-Mn alloy decomposes in 5 days in moist air. In pure O_2 this phenomenon is notably retarded. The stability of an Al-Mn alloy with 20% Mn is twice that of a 25% alloy. (6) Al-Ni alloys with 25%, 20% and 15% Ni are on the market. Method same as under (5). Ni alloys more readily with Al than Mn. Constant stirring during casting counteracts the tendency of Al-Ni towards segregation. Al-Ni is more stable in air than Al-Mn. (7) Al-Si intermediate alloys contain 13-50% Si. The latter is added in the solid state to Al melts. Al-Cu-Ni and Al-Ni-Si alloys are considered briefly. EF (3a)

Can Copper, Bronze, Red Brass and Brass Successfully be Melted in the Cupola? (Kann man Kupfer, Zinnbronze, Rotguss und Messing im Kupolofen einwandfrei schmelzen?). Willi Claus. *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, Aug. 19, 1934, pages 349-352. In the first chapter the theoretical aspects of melting Cu and Cu alloys in the cupola are discussed with special reference to the solubility of gases in these metals and alloys. C, CO, CO_2, N, H_2O vapor and hydrocarbons are practically or absolutely insoluble in these materials. O is dissolved in liquid Cu with formation of Cu_2O. In Cu base alloys O forms oxides, giving slags. H is dissolved to a considerable degree in an irreversible process. SO_2 is dissolved by Cu in a reversible solution process, in Cu base alloys in an irreversible process. In the 2nd chapter, literature on technical application of melting these metals and alloys in cupola is discussed in chronological order. It is stated that as far back as 1898 the cupola was used for this purpose by a German foundry. In recent years the cupola has been applied in the United States on a large scale. The advantages of melting in a cupola are: increased melting capacity and higher efficiency of melting process. This melting process in addition to the processing of ingot material permits the use of waste material. GN (3a)

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Study of Casting Properties of Metals and Binary Alloys (Etude des propriétés de fonderie des métaux et alliages binaires). P. BASTIEN. *Revue de Métallurgie,* Vol. 31, June 1934, pages 270-281; July 1934, pages 324-329; Aug. 1934, pages 369-373. Experiments were conducted with the spiral mold proposed by Guillet and Portevin, *Comptes Rendus,* Vol. 183, 1926, page 634, improved by Courty, *Revue de Métallurgie,* March 1931, pages 169-182; Apr. 1931, pages 194-208. Overheating above the melting temperature from 100° to 300°C. increases the "flowing properties" of Sn, Pb, Cd, Zn, Sb and Al as a straight line function of the temperature, with the slope depending on the nature of the metal. Flowing properties depend on the temperature of the chill. The slope of the curves obtained experimentally do not agree with the classification on the theoretical basis. Sb-Pb system composed of two solid solutions and one eutectic, Sb-Cd system having two eutectics and Sb-Sn system with a three branch liquidus were investigated by plotting the length of the casting spiral against the corresponding composition point on the equilibrium diagram. Flowing properties vary inversely proportional to the interval of the solidification. They depend on the aspect of the solidification and are comparatively much higher when definite components form on crystallization instead of dendritic crystals composed of solid solutions approaching pure metals. Rapid increase in the flowing properties near the eutectic point can be explained by the lack of consecutive precipitation of the constituents interfering with the flow of the liquid phase. No influence of viscosity on the flowing properties was observed. Mg-Al and Mg-Cu alloys were investigated in an apparatus similar to the standard but made of a mixture of green sand (18 parts), flowers of sulphur and boric acid (one part of each). Maximum flowing properties were observed for Mg_4Al_3 and they varied inversely proportional to the interval of solidification. Addition to industrial Mg alloys of either Cu or Al increases their flowing properties at a given temperature. Remelting of 94Mg-6%Al alloy decreases the flowing properties with the increase of oxides and nitrides present and increases with lowering of Mg content. Flowing properties of Mg alloys in different sands were determined. Sands containing 3, 6, 9 and 35% S, 3 and 6% NH_4F, 10% Na_2SO_4-3% S, 6% pulverized boric acid, 12% Na_2SO_4-0.5% S, 20 and 40% ferrosilicon and dry sand containing 3% S were investigated. Flowing properties vary inversely with the cooling power of sand. Dry sand with 3% S has poor cooling power. Sand with 6% boric acid, 20 and 40% ferrosilicon has good cooling power increasing in the order given. The rest have a medium cooling power. Apparatus for determination of contraction is described. Metals cast in chills have a smaller contraction than cast in sand. Addition of Al and Cu to Mg diminish shrinkage of Mg. The former gives 2 minima for saturated solid solutions. Cu rapidly reduces contraction up to 8% and then more slowly up to 32% Cu. Shrinkage cavity of cylindrical cast specimens is limited to the top surface only. Diagram showing the relation between Al and Cu additions and the amount of shrinkage cavity formed is given. The paper is illustrated with 36 diagrams. JDG (3a)

Aluminum Founding (Aus der Praxis des Aluminiumgiessers). M. SCHIED. *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, Sept. 16, 1934, pages 388-392. Author discusses Al founding in detail and gives many practical hints to obtain sound castings. Points considered: (1) material of charge, (2) testing suitability of charge, (3) choice of crucible, (4) melting procedure, (5) purification of metal bath, (6) casting temperature, (7) mold making, (8) arrangement of gates and risers, (9) application of chills, (10) method for avoiding cracks, (11) surface appearance of casting. Use of gray cast Fe crucibles is more economical than graphite crucibles. Coating of Fe crucibles with a mixture of Mg powder and tar is advisable. Since Al and its alloys absorb gases readily the melt should be fluxed (85% NaCl + 15% CaF_2) and melted rapidly. The casting temperature should not be estimated but always accurately measured with an immersion pyrometer. Powdered coal should not be used in molding sand. Direct gating must be avoided. With long castings oblique arrangement of mold is advisable. Author finally touches upon application of chill molds and special points of importance of obtaining a silver bright surface appearance on castings. GN (3a)

Pressure Molding (Le Moulage sous Pression). F. NIELSEN. *Bulletin de l'Association Technique de Fonderie,* Vol. 8, Mar. 1934, pages 106-115. Possibilities of pressure molding, planning and construction of the molds and the injection of the metal. WHS (3a)

Manufacture of Special Cast Irons (Fabrication des Fontes Spéciales). A. GUEDRAS. *Revue de Fonderie Moderne,* Vol. 28, Sept. 25, 1934, pages 270-271. A brief general review of methods used in the production of cast irons of special quality. Furnace deoxidation and desulphurization are briefly discussed. Ha (3a)

Smelting of Storage Battery Scrap (Zur Verhüttung von Akkumulatorenabfälle). E. T. RICHARDS. *Die Metallbörse,* Vol. 24, May 5, 1934, pages 505-506. About 50% of the Pb scrap in Germany comes from storage batteries. The smelting of this type of scrap particularly of the slime has not been satisfactorily worked out. Small quantities (below 5% of the total metallic content) are added to the Pb blast furnace charge. The author successfully melted down storage battery slime in a small shaft furnace by mixing it (15%) with charcoal and old slag rich in Fe. The total Pb loss was 5-7% not including the flue dust which could be recovered. The smelting procedure in the Ford plant is described. A 40 ton shaft furnace containing a grate of Ni-Cr bars for carrying the charge is employed. The charge consisted of 150 kg. Pb scrap, 37.5 kg. coke, 23 kg. $CaCO_3$, 8kg. CaF_2 and 13 kg. Fe scale. Treating only battery slime in a reverberatory furnace is practically impossible. Adding gradually a mixture of slime + coal or of slime, Fe oxide, coke, soda and finely ground Pb ores rich in SiO_2 to a molten Pb bath at 1000°-1200° C. is not always advisable due to the presence of relatively large quantities of Sb in the battery scrap. The recently introduced Newman hearth, a cast Fe trough, operates at metal loss of 15-18%. EF (3a)

Gases in Metals with Particular Reference to Non-Ferrous Metals (Ueber Gase in Metallen, mit besonderer Berücksichtigung der Nichteisen-Metalle). W. KOCH. *Zeitschrift für technische Physik,* Vol. 15, 1934, pages 280-284. Methods employed in determining gas content of metals are reviewed. Of these, the hot extraction process is considered the most reliable. Gas content of commercial Al was found to be 1-2 cc./100 g. metal; for electrolytic Zn gas content was proportional to the square root of the current density employed in electrolysis. Solubility of H_2 and N_2 in Al, Cu and alloys of these metals, and of H_2, N_2, CO and CO_2 in Cu and Cu alloys are tabulated. Tables illustrate relation between solubility of a gas and constitution of an alloy for different pressures. 7 references. Ha (3a)

Brass Foundry Practice. H. M. ST. JOHN. *Industrial Heating,* Oct. 1934, pages 35-40, 46. Construction, charging and operation of furnaces is reviewed, defects commonly encountered in castings described and means to obtain sound castings are discussed. Addition of Pb up to 10% will improve machinability. The proportion of Sn need not be much above 2% (the machinability will suffer if it is) unless a high elastic limit is needed. Ni not in excess of 2% improves density and uniformity of structure without impairing machinability. Melting practice, mold layout, and items making up total costs of a casting are discussed. Ha (3a)

Ferrous (3b)

C. H. HERTY, SECTION EDITOR

Non-metallic Inclusions in Steel. Part I. Products of Deoxidation. STEPHEN F. URBAN & JOHN CHIPMAN. *American Society for Metals Preprint* No. 21, 1934, 18 pages. Oxide inclusions formed by deoxidation with Mn, Si, Zr, Ca, Al and Cr in ferro-alloys have been studied in steels as cast, quenched, annealed and forged conditions. A limited number of inclusions, ferrous silicates low in silica and Mn silicate inclusions were affected by quenching and annealing. Small additions of Si produce ferrous silicate inclusions while large additions nearly pure silica inclusions. Segregated portions of pure silica are found in highly fluxed inclusions of low total silica content. Precipitation of silica in these inclusions occurs at 1830°F (1000° C.). From studies in polarized light inclusions formed when Cr is added to a steel bath appear to be chromite and additions of Al result in ferrous aluminates of uncertain composition. Method for removal of individual inclusions is described and petrographic method for classification of silicate inclusions proposed. 16 references. WLC (3b)

Fly Wheels (Schwungräder mit vollem Boden). *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, July 8, 1934, pages 279-285. Discusses various points to be observed in molding and casting disc shape fly wheels. Molding method, arrangement and treatment of mold and casting procedure require careful attention in order to obtain sound castings. GN (3b)

Making a 95 ton Anvil Block. J. ROXBURGH. *Iron & Steel Industry,* Vol. 7, Dec. 1933, pages 71-73. An iron with Si 1.2 to 1.3%, total C 3.2 to 3.3%, P 0.5% max., S 0.08% to 0.1%, Mn 0.4 to 0.6% is recommended. Melting, molding, core, gate and riser, pouring and finishing practice are discussed. CEJ (3b)

Refractory Materials for the Iron and Steel Industries. ALFRED B. SEARLE. *Iron & Steel Industry,* Vol. 7, Jan. 1934, pages 115-117. Test of refractoriness-under-load is most valuable single test of a refractory material. Inventions have been few and improvements gradual. Specifications tend to be increasingly stringent. Author reviews the work of other investigators regarding furnace and oven linings. A short discussion of the properties, treatment and control of refractory molding sands is included. 21 references. CEJ (3b)

Bessemer Steel, Revival of its Manufacture in Great Britain. L. P. SIDNEY. *Iron & Steel Industry,* Vol. 7, Jan. 1934, pages 121-124, 133. Due to economic causes and prejudice basic Bessemer steel production in Great Britain has dwindled. Control of production, however, has improved. Pig iron suitable for conversion in a basic lined converter should be low in S, P about 3%, Mn about 2.5%, Si less than 1%. Yield of this process of steel making is about 82 to 85% of the pig iron charged. Slag is marketable as fertilizer. Prospects of revival highly promising. CEJ (3b)

Electric Steel Practice in 1933. VICTOR STOBIE. *Iron & Steel Industry,* Vol. 7, Jan. 1934, pages 125-128. Electricity is cheaper than coke for steel melting and it is a more easily controllable heating medium than the producer-gas of the open-hearth furnace. Arc melting furnaces up to 100 tons capacity and high-frequency induction furnaces up to 5 tons are now in use. These capacities may be further increased when steel makers so desire. Bricks containing 45% alumina for roof construction of arc furnaces are most economical. The use of a refractory extension to the top of the crucible above the inductor coal permits the refining of the steel in the high-frequency furnace. Experiments with electric furnace refractories showed that those which absorbed most iron oxide from a steel sheet on which they were heated gave the poorest results when used for furnace construction. Both arc and high-frequency electric melting gaining. CEJ (3b)

The Effect of the Temperature and the Rate of Pouring on the Quality of Medium Carbon Steel. YU PROKHOROV. *Stal,* Vol. 4, Apr. 1934, pages 38-50. A higher pouring temperature increases the mechanical properties, decreases the size and no. of slag inclusions, and causes a coarser macrostructure. The best pouring temperature was found to be 1420-1460° C. The rate of pouring has no effect. HWR (3b)

Alloys Losses in the Basic-Electric-Arc Furnace (Abbrandverhältnisse in basischen Lichtbogen-Elektrostahl-Oefen). E. PAKULLA & K. RUDNIK. *Stahl und Eisen,* Vol. 54, June 14, 1934, pages 621-629, June 28, pages 676-680. The elements W, Mo, V, Cr, Mn, Ni, and Co were studied in respect to their losses in the basic-electric-arc furnace. The results are shown in curves indicating also the effect of concentration of the element and length of time in furnace. W showed the greatest loss, then followed Ni and Co, Cr and Mn. The losses of Mo and V were smaller but no direct comparison could be made because the contents of these elements in the melts studied were smaller. SE (3b)

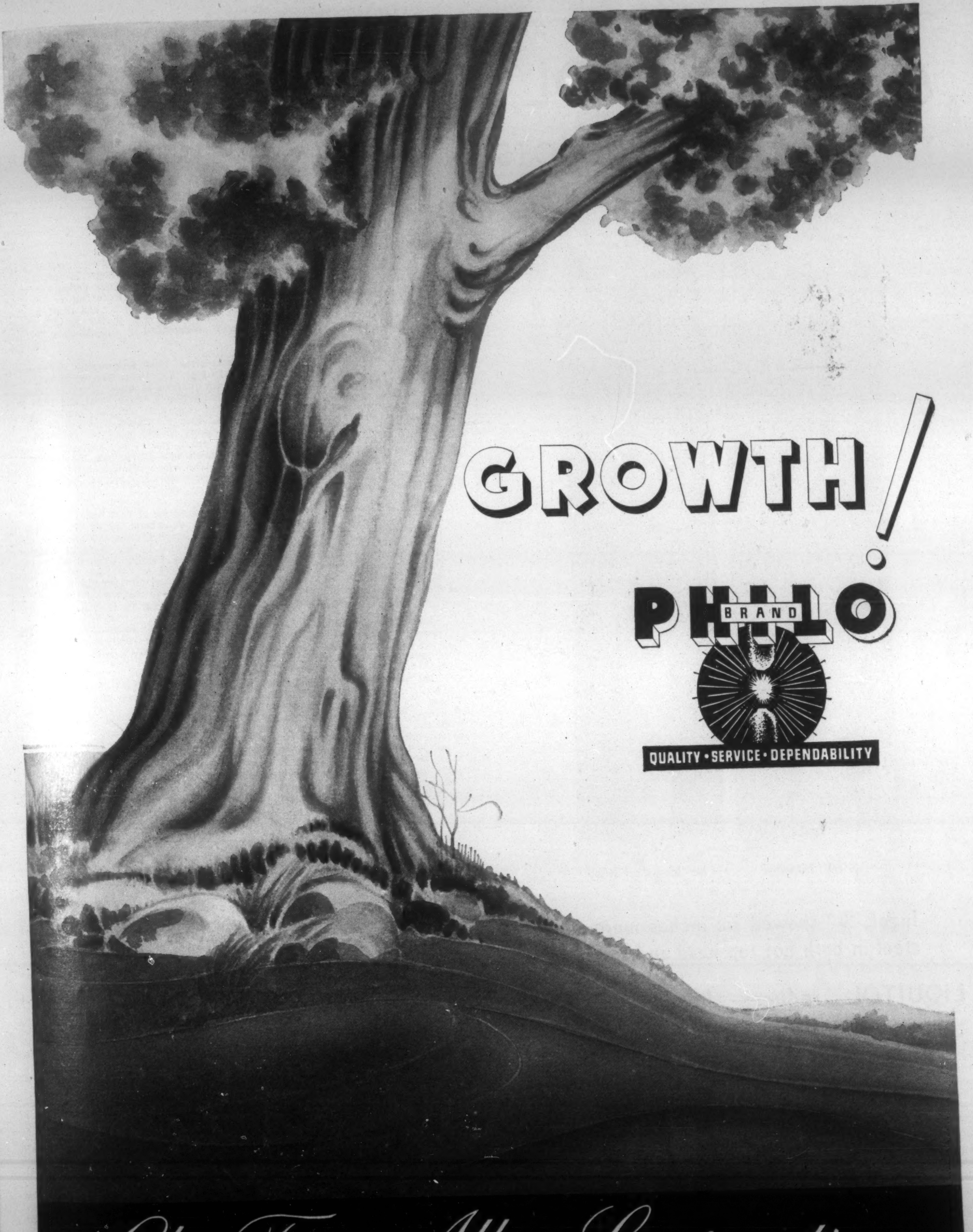
Tungsten and Chromium Alloys in Alloy Steel Making (Wolfram und Chromlegierungen in der Edelstahlerzeugung). B. MATUSCHKA. *Stahl und Eisen,* Vol. 54, Aug. 16, 1934, pages 845-853. Chemical analyses and micrographs are shown indicating the impurities in various commercial ferro-W and ferro-Cr alloys. For the production of quality alloy steel the use of double refined sintered W instead of ferro-W and of ferro-Cr made by the silico-thermit process is recommended. SE (3b)

Moulding Machine Practice. Recent Progress Registered. *Foundry Trade Journal,* Vol. 50, Mar. 15, 1934, pages 180-182. Report of paper by F. E. Steele on the progress of machine molding practice, together with discussion of same. Paper deals with early molding practice, hand ramming machines, hand squeezing machines, pneumatic jolt machines, and sand-slingers. OWE (3b)

Construction and First Months of Operation of the New Open Hearth Plant at Makejewka. M. TATAROV & D. SMOLYARENKO. *Domez,* No. 5, 1934, pages 1-8. (In Russian). Detailed account of the operation during 4 months of the two furnaces already completed out of 12 planned. (3b)

Electric Furnace Cast Iron (Pratique de la Fonte Electrique). H. H. WALTHER. *Bulletin de l'Association Technique de Fonderie,* Vol. 8, July 1934, pages 315-322. A.F.A. exchange paper presented at the Nancy Foundry Congress, July 1934. Advantages and disadvantages of electric furnace melting, control of melting, superheating, costs, and melting methods, as well as the physical properties of electric furnace cast iron, are discussed. The electric furnace produces a superior product at a higher cost. WHS (3b)

Sodium Carbonate in Iron and Steel Works. N. L. EVANS. *Iron & Steel Industry,* Vol. 7, May 1934, page 257. Abstract of paper read before Sheffield branch of the Institute of British Foundrymen, Mar. 1934. See "Use of Sodium Carbonate in Iron and Steel Works," *Metals & Alloys,* Vol. 5, Aug. 1934, page MA 385. CEJ (3b)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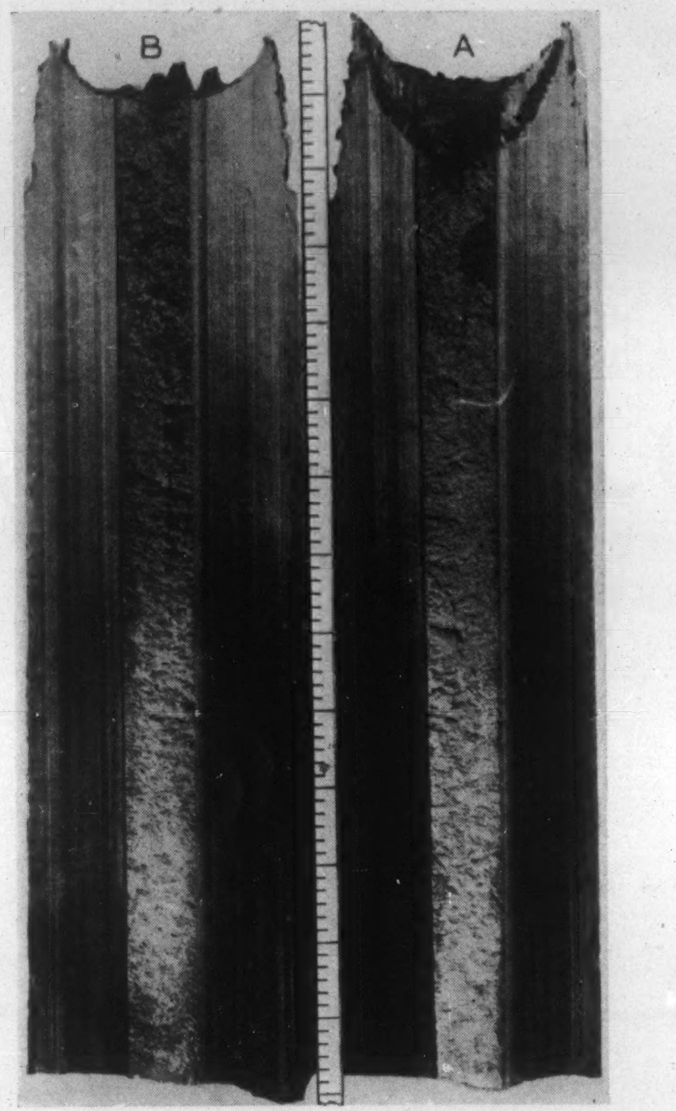

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The Formation of Ghost Lines in Silicon Killed Steel Ingots (Die Bildung von Schattenstreifen in silizierten Stahlblöchen). F. BARDENHEUER. *Stahl und Eisen,* Vol. 54, Oct. 18, 1934, pages 1073-1081. Several large ingots of low and medium C and alloy structural killed steel were sectioned, S printed and etched with Oberhoffer's reagent to reveal the ghost lines. These were observed in the dendrites adjacent to the columnar crystalline rim. Their size increased toward the top of the ingot. Sulphides also were segregated in this zone just within the columnar crystals. Larger ingots, higher pouring temperature, slow cooling, and in general all conditions which favored coarser primary crystallization and segregation, favored the formation of ghost lines. The course of the ghost lines was found to be outlined by porosity and entrapped gas; presumably the steel had not been so completely killed as to entirely prevent the evolution of CO gas. SE (3b)

Reaction Course of the Acid Open Hearth Process (Über den Reaktionsverlauf beim sauren Siemens-Martin Verfahren). P. BARDENHEUER & G. THANHEISER. *Die Naturwissenschaften,* Vol. 22, June 1, 1934, pages 393-395. The object of the present investigation was to establish the significance of the 2 main reactions between bath and slag: $FeO + Mn \leftrightarrows MnO + Fe$ and $2\,FeO + Si \leftrightarrows SiO_2 + 2\,Fe$ with reference to the interpretation of the acid open hearth process. The concentration changes of C, Si, Mn and O in the metal bath in dependence on time are graphically presented. It has been revealed that at the initial stages of the acid open hearth process, bath and slag undergo changes in the direction of a state of equilibrium. This equilibrium, however, is upset during the course of the melting process due to the presence of the high C content of the melt. By reducing SiO_2 in the furnace lining the bath becomes richer and richer in Si as would correspond to the equilibrium. Towards the end of the melting process, the elimination of C is almost exclusively accomplished by SiO_2 whereby the melt enriches in Si. EF (3b)

Open-Hearth Slag Tests (Die Schlackenprobe beim Siemens-Martin-Verfahren). R. BACK. *Stahl und Eisen,* Vol. 54, Sept. 13, 1934, pages 945-954. Slag samples were poured into flat circular molds to form pancakes 12 cm. in diameter 2 cm. thick. From the appearance of the surface of these cakes and from their shape—whether they were flaky or frosted, furrowed, wrinkled, cracked, spider-webbed, or smooth, concave or convex—and from the fractures, it was possible to judge the composition of the slag fairly closely in respect to the CaO-SiO_2 ratio and the MnO and FeO content. Detailed descriptions of the appearance of cakes of various types of slag are given with explanations for judging the composition. By means of such slag tests it is claimed that the working of basic open-hearth heats can be constantly controlled to give better steel and effect a large saving in manganese consumption. SE (3b)

Effect of Linseed Oil Molds or Cores on the Structure of Cast Iron (De l'Influence de l'Huile de Lin Incorporée dans les Sables de Moules ou de Noyaux sur la Texture de la Fonte). *Bulletin de l'Association Technique de Fonderie,* Vol. 8, July 1934, pages 330-335. Paper presented by the Technical Committee of the Belgian Foundry Association at the Nancy Foundry Congress, July 1934. The best results, in respect to hardness and porosity of the sand, were produced by raw linseed oil, when compared with refined linseed oil and mineral oil. Linseed oil molds or cores produced a refining effect on the structure of the metal and even a chilling of the surface in metals which were susceptible to chill. WHS (3b)

High-Frequency Electric Furnace Production—Marked Increase in Ingot Size. *Foundry Trade Journal,* Vol. 50, Mar. 8, 1934, page 169. Brief note showing 2-ton ingots which have been produced by Samuel Fox and Co., Ltd., in their high-frequency electric furnace. OWE (3b)

The Estimation of Tapping Heat in the Basic Open Hearth Process. *Iron & Steel Industry,* Vol. 7, Feb. 1934, pages 173-176. A steel furnace should never have its metal above the temperature necessary to tap at any time during the process. Estimation of temperature is important to avoid losses of output, gassy metal, imperfect ingots, reduction in life of molds and ladles. Indications of temperature may be obtained from the effects of additions. Three methods of testing the heat of the metal are described and discussed: (1) the rod test depending on the effect of the molten metal on steel rod inserted into the metal, (2) the spoon test is a very useful test which depends on the physical properties of a metal sample withdrawn from the furnace by means of a slag coated spoon, (3) the pyrometric method, the temperature being estimated by an optical pyrometer of the disappearing filament type. Whole field calls for comprehensive research. CEJ (3b)

Better Products From Improved Melting Furnaces. *Metal Progress,* Vol. 26, Oct. 1934, pages 73-76. Uses of induction furnaces for vacuum melting of alloys in production are discussed. Top-charging of direct arc furnaces is described and increasing use of direct arc and indirect arc furnaces for production of cast irons are discussed. WLC (3b)

A Difficult Casting (Ein schwieriger Guss). *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, Aug. 19, 1934, page 524. Brief description of molding and casting procedure in founding the anvil of a large steam hammer. Casting weighed 90,000 kg. GN (3b)

Molding of Ribbed Pipes on Vibration Molding Machines (Ueber das Formen von Rippenrohren auf Rüttelformmaschinen). *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, Apr. 29, 1934, pages 186-187. Since special care is required for attaining a dense sand mold in making ribbed pipes manual molding is not advisable. Best molding method is to use shock-free vibration molding machine. Working method is described. GN (3b)

The Application of Calcium-Silicon in the Foundry (Die Verwendung von Calcium-Silizium in der Giesserei). *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, Sept. 2, 1934, pages 365-367. Discusses application and advantages of Ca-Si as deoxidizer of Fe and steel melts. Average composition: 34% Ca, 60% Si, 2% Al, balance Fe. Advantages: (1) low melting temperature of deoxidation products (2) rapid agglomeration and disintegration within slag, (3) high fluidity of finished metal. Ca-Si is added in ladle in small portions since its deoxidizing action is very energetic. Ca-Si has successfully been applied in melting soft steels with low Mn and Si content, case hardening steels, spring steels, etc. In Fe founding use of Ca-Si is advisable in particular when charge contains a rather high percentage of steel scrap. GN (3b)

Making the Mold of the Wheel of a Pelton Turbine (Herstellung der Form für das Laufrad einer Pelton-Turbine). *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, Apr. 29, 1934, pages 176-178. The wheel provided with 20 blades having a diameter of 1200 mm. and weighing 1450 kg. was molded with sweep. The molding method is described in detail. GN (3b)

Molding and Casting of Locomotive Castings for the German Railway (Formen und Giessen von Lokomotivguss für die Deutsche Reichsbahn). *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, Sept. 30, 1934, pages 411-412. This first installment on a series of papers dealing with processing of locomotive castings discusses material, molding and casting of the slide plate of a crosshead. Difficulties first encountered with various molding methods are outlined. Sound castings were then obtained by molding the pieces by 2 in a flask, arranging the gate between the 2 pieces, gating from bottom and applying a horn gate. No riser and sink head were used. Proper choice of sand and drying of mold is pointed out. GN (3b)

WORKING OF METALS & ALLOYS (4)

Rustless Steel (Rostfreier Stahl). H. Bohr. *Zeitschrift Verein deutscher Ingenieure,* Vol. 78, Oct. 6, 1934, pages 1172-1173. A few directions are given for the treatment of rustless steels in manufacturing processes: forge cutlery steel carefully, do not harden too low and temper too high; all hardening scale must be removed; internal stresses due to cold-working must be relieved by short annealing; pickling must last a short time only. In order to stay rustless surfaces must be highly polished. Ha (4)

Rolling (4a)

RICHARD RIMBACH, SECTION EDITOR

Elastic Rolling Mill Coupling (Elastische Walzwerk kupplung). Fr. Engel. *Zeitschrift Verein deutscher Ingenieure,* Vol. 78, June 30, 1934, pages 811-812. Grid-like springs are placed in tapering slots at the circumference of the 2 coupling halves which permit axial as well as transverse displacements without dead play in normal position. A coupling for transmission of 23000 h.p., max. 50000 h.p., is described. Ha (4a)

Theory of Calibration of Rolls for Flat and Angle Iron. A. P. Chekmarev. *Domez,* No. 6, 1934, pages 13-20 (In Russian). A new method for pass design is offered based both on the mathematical treatment and experience of several successful mills. (4a)

The Manufacture of Full-Finished Steel Sheets. Eric R. Mort. *Iron & Steel Industry,* Vol. 7, June 1934, pages 304-307. Abstract of paper read at annual meeting of Iron & Steel Institute. See *Metals & Alloys,* Vol. 5, Oct. 1934, page MA 474. CEJ (4a)

Precision Rolling (Genauigkeitswalzung). A. Nöll. *Stahl und Eisen,* Vol. 54, Aug. 30, 1934, pages 893-898. The effect of condition of the work, rolling procedure, and type of mill on accuracy of dimensions in rolling is discussed, particular attention being paid to roll design. How increased precision may be obtained is illustrated by the rolling of rounds. SE (4a)

Influence of Friction on the Flow of the Work in Rolling. (Einfluss der Reibung auf den Werkstofffluss beim Walzen). E. Siebel. *Stahl und Eisen,* Vol. 54, Oct. 11, 1934, pages 1049-1057. An exhaustive study was made of the effect of friction between the rolls and the work on the shape of the rolled bar, particularly on spreading. To demonstrate the importance of friction various metals were rolled cold using smooth and roughened rolls. SE (4a)

Forging & Extruding (4b)

A. W. DEMMLER, SECTION EDITOR

Production and Working of Stainless Steels (La produzione e la lavorazione degli acciai inossidabili). M. Gatti. *La Metallurgia Italiana,* Vol. 26, June 1934, pages 420-428. A survey of the methods of producing and working stainless steels including cold-working and heat-treatment. Special attention is paid to the production of austenitic laminated types. The induction furnace is suggested as offering a means of producing stainless steels more economically. AWC (4b)

Collapsible Tubes. *Tin,* Sept. 1934, page 8. The extruding process in the manufacturing of collapsible tin tubes for pastes, polishes, etc. is briefly described; a pressure of 50-100 tons is exerted on the die. The Sn is alloyed with 0.5% Cu to make it harder. Ha (4b)

Advances in Forging Practice and Machinery. *Metal Progress,* Vol. 26, Oct. 1934, pages 157-160. Development of more precise machinery for the production of forgings to much closer size is described and reference made to other discussions in greater detail. Forging steels and their uniformity control are briefly discussed. WLC (4b)

Steps in Welding Weldless Jars. J. B. Nealey. *American Machinist,* Vol. 78, Sept. 26, 1934, pages 672-674. Sequence of operations in hammer-forging practice for intricate parts is described. Ha (4b)

Designs That Can be Made by Impact Extrusion. Herb. H. Hall. *Product Engineering,* Vol. 5, Sept. 1934, pages 341-343. Can-shaped parts with thin walls and thick bottoms, and bosses, lugs, etc., integral with bottom part, are made by impact extrusion, i.e., a squirting operation whereby the metal (which must be extremely ductile) squirts out through the annular opening between punch and die when the former is forcibly brought down on the metal in the latter. Sn, Pb and Al are suitable for this process, particularly Al, as both strength and stiffness are added to the finished product which can be annealed at 800°F. for about 20 min. if the part should be soft and pliable. Examples are shown. Ha (4b)

Cold Working, including Shearing, Punching, Drawing & Stamping (4c)

Machining and Materials (Zerspanung und Werkstoff). E. Brödner. VDI Verlag, Berlin, 1934. Cloth, 6¼ x 8¼ inches, 173 pages. Price 5 RM.

The first half of the book concisely discusses the variables in all types of machining operations, and for each type presents information on tool angles, speed and feed, usually by charts or nomograms. Cutting compounds are discussed, as are the mounting and operation of grinding wheels. This part of the book is written from the point of view of the machine shop engineer. The latter half deals first with the metallic materials to be cut, largely from the metallurgical point of view, listing the usual properties. Then follows a description, with composition and heat-treatment temperatures of commercial German tool and high speed steels, tungsten carbide tools (with data on tool angles, speeds, feeds, etc. for a variety of materials cut) and finally a discussion of the mounting and use of diamond tools. A bibliography of some 700 references (overwhelmingly German) and an index complete the book.

A good picture of German machine shop practice is given in condensed form, which will be of interest to production engineers and to metallurgists engaged in manufacture of cutting tools.

Various sizes of type, and bold black lines beside a sentence now and then, are utilized to draw the reader's attention to specially important statements. The treatment is concise and crisp, the average sentence is very much shorter than is common in German technical publications. It is a useful handbook.

H. W. Gillett (4c) -B-

Alloy Cast Irons for Press and Draw Dies in the Sheet Metal Industries. A. B. Everest. *Sheet Metal Industries,* Vol. 8, May 1934, pages 281-283. Discusses irons to be used "as cast" and also heat-treatable types. Nickel additions make for heat treating possibilities. Four types of iron are set forth and the uses for each are outlined. AWM (4c)

How to Arrange a Modern Plant for Drawing Soft Steel Wire (Comment réaliser une Tréfilerie moderne d'Acier doux). A. Cotty. *Usine,* Vol. 43, May 10, 1934, pages 29, 31. Layout and equipment, speed of machinery, and drawing schedule are described for drawing soft steel wire from #1 to #18 gage. Ha (4c)

Cold Drawn Steel Spring Wire. Edw. J. P. Fisher. *Wire & Wire Products,* Vol. 9, Sept. 1934, pages 287-297. The requirements on materials for making quality cold-drawn high C steel spring wire are discussed exhaustively. It is usually made of basic open-hearth steel with carefully selected charge of pig and scrap. The ingot has a composition of 0.50-0.70% C, 0.9-1.2% Mn, 0.04% max. P, and 0.045% max. S. Excess segregation in the ingot of C, Mn, P is prevented by increase of speed of freezing and using hot tops. When drawn the wire is heated above the critical range (1800°-1850° F.) to transform the hot-rolled or cold-drawn structure completely to a homogeneous solid solution of iron carbide in γ-iron, i.e. austenite; the heat is held to allow growth of large grains of austenite, the material is then cooled in air to obtain a uniform dispersion of insoluble spherical particles of iron carbide throughout the mass of α-Fe with minimum precipitation of free masses of α-Fe at the old austenite grain boundaries; this is the sorbite or sorbito-pearlitic structure. Treatment, furnaces, equipment and drawing practices to obtain these ends are described, micrograms of structure illustrate the quality of material. Ha (4c)

Studies of the Wire-Drawing Process. Part IV—The Angle and Contour of the Die. E. L. Francis & F. C. Thompson. *Iron and Steel Institute, Carnegie Scholarship Memoirs,* Vol. 22, 1933, pages 1-13. Using straight tapered dies the best angle for most work is 6°. This is really the semi-angle that is implied. Deviation from this angle in either direction sets up a greater frictional loss. However, a rather smaller angle is necessary where the reduction in the draft is small, especially with hard materials. For austenitic type steels the best die appears to be a plain cone of 5° to 5½° angle. For hot rolled rod where lubrication presents difficulties a much steeper angle may be required and might well be 10° to 11°. Alternately one might use a radial taper die giving a high angle where the metal enters and decreasing to about 6° at the point of exit. The die angle is not affected by speed of drawing, nature of lubrication, nor carbon content, as long as the steel is not of the austenitic type. The reduction of area has little effect. The best angle for a 35% reduction is 5¼° and 6° for a 20% reduction. The investigations were done using carbon steels 0.085 to 1% carbon, a 30% Ni, nickel-silver alloy, "staybrite," and aluminum. The tests included 20, 30, 35, and 44% reductions of area. Tungsten-carbide dies were used. The authors think that similar conditions would prevail if steel dies were used. Mostly, wire was drawn from 0.072" to 0.064", some from 0.08" to 0.064". The ideal angle may vary for other values of original cross sectional area. 7 references. CW (4c)

Studies of the Wire-Drawing Process. Part V.—Experiments with a Rotating Die. E. L. Francis & F. C. Thompson. *Iron and Steel Institute, Carnegie Scholarship Memoirs,* Vol. 22, 1933, pages 15-30. Low and high speeds of drawing were used in the tests. Tungsten carbide type dies were used. The power required to turn the die was measured by an ammeter calibrated in terms of output in ft. lbs. per min. Results using a 7% nickel-silver wire, 25% reduction of area, a die semi angle of 6°, and a good lubricant showed by a comparison with stationary die data that there is a considerable reduction of drawing load when the die is rotated relatively slowly. The slow speeds of drawing varied from 0.056 to 3.219 in. per min. and the rate of rotation of die from 80 to 160 r.p.m. The reduction of drawing load is most pronounced at a minimum speed of drawing. There was considerable discrepancy between tests on the nickel silver and a 20% nickel cupro-nickel. For high drawing speeds, 60 ft. per min., and a speed of rotation of die 3360 r.p.m., the results were disappointing, as about the same tension was required for a 20.8% reduction using a stationary and rotating die respectively. Both a mild steel and 70:30 brass wire were tested. It is shown in the appendix that the mechanical properties, structure, recrystallization temperature, and rate of subsequent grain growth of a 0.085% carbon steel are little affected by changing from stationary to rotating dies. 5 references. CW (4c)

Studies of the Wire-Drawing Process. Part VIA.—Some Experiments Bearing on the "Casting" of Wire. A. S. Kenneford & F. C. Thompson. *Iron and Steel Institute, Carnegie Scholarship Memoirs,* Vol. 22, 1933, pages 31-49. The paper lists preliminary experiments relating to the influence of casting on wire drawing and this memoir represents the first of those dealing with the subject. The research deals with factors which influence the curvature of a wire as it leaves the die together with a few determinations of the properties of the wire and some pertinent measurements of the pull required. In the tests a 0.085% carbon steel was used, original diameter 0.072" and fully annealed. Tilting the die and using various "Widia" dies of 3°, 5½°, 14°, and radial tapers to give 21% reduction of area showed that minimum radius of curvature in the resulting wire occurs when the tilt is 20°. The pull required for drawing is a minimum for the 5½° die. Varying the reduction of area caused a movement of the minimum radius of curvature. At 4% reduction the minimum occurred at 40° tilt, at 46% reduction it occurred at about 8° tilt. Meager evidence showed that previous cold work influences the curvature markedly for moderate reductions. For severe deformation the influence of previous cold work appeared to be small. Increasing the speed of drawing increased the value of the minimum radius of curvature of resulting wire. At the various spreads the minimum occurred when a 20° tilt of die was used. Heating the die resulted in a continuous decrease of pull required up to 175° C. at which temperature the lubricant broke down. Microstructures are presented but no differences were observed after various tests. Authors state no discussion of the complex results is attempted. 3 references. CW (4c)

Effect of Degree of Drawing and of Tempering on the Internal Stresses in Steel Wire (Einfluss des Ziehgrades sowie des Anlassens auf die Eigenspannungen in Stahldrähten). H. Bühler & W. Püngel. *Archiv für das Eisenhüttenwesen,* Vol. 8, Oct. 1934, pages 165-168. The internal stresses in the drawn wires were determined by the method of Linicus and Sachs; in this half the cross-section of a length of the wire is ground off on one side and the internal stresses calculated from the resultant bowing. Wire of 0.54 and 0.84% C were studied. At reductions beginning at about 20% tensile stresses appear at the surface and compressive stresses in the interior; with increasing reductions the stresses rise to a maximum and may even go through a reversal. The pretreatment, annealing or patenting, is without noticeable influence on the internal stresses. After tempering at 250° to 450° C., higher stresses are generally left, the higher the original internal stresses. At 250° C. the stresses are lowered appreciably only after 5 min. tempering; at 350° C. the stresses are reduced 55% after 1½ min.; at 450° C. there is a 70% reduction after 5 sec.; at 550° C. there is practically complete stress release after 5 sec. SE (4c)

The Bending of Thin Tubes. *Machinery,* London, Vol. 44, June 14, 1934, pages 307-308. Bendalloy, an alloy containing Bi, Pb, Sn, and Cd and having a melting point of 160° F., is used as a filler material in bending operation. The method can be applied to the bending of copper, brass, duralumin, steel, and stainless steel tubes. The molten metal is poured into the tube filled with boiling water and then quickly chilled to develop a fine crystal structure that will resist cracking when the tube is bent. Tubes filled with the metal can also be rolled, drawn, swaged, cold pressed, or forged to desired shapes. Kz (4c)

Simple Forming Operations on Stainless Strip for Radiator Moldings. *Steel,* Vol. 94, June 25, 1934, page 30. Describes methods of Motor Products Corp., Detroit, Mich. MS (4c)

Relations between Deep-Drawing Qualities and Mechanical Properties of Different Metals (Beziehungen zwischen den Tiefzieh- und den Festigkeitseigenschaften verschiedener Metalle). M. H. SOMMER. *Zeitschrift Verein deutscher Ingenieure,* Vol. 78, Oct. 13, 1934, pages 1195-1201. Experiments were made with sheets of Cu, brass, Al, and different rustless Cr-Ni steels which revealed close relations between the physical properties and deep-drawing quality. The stresses occurring in deep-drawing were determined and mathematical expressions for them derived, and this led to diagrams of effective deep-drawing curves for each material so that the limit for drawing can be determined. Curves and actual measurements showed agreement. Ha (4c)

Effect of Annealing Time on Recrystallization and Recovery of Cold Worked Metals (Der Einfluss der Erhitzungszeit auf die Rekristallisation und Erholung bei kaltbearbeiteten Metallen). J. A. M. VAN LIEMPT. *Recueil des Travaux Chimiques des Pays-Bas,* Vol. 53, July 15, 1934, pages 941-948. The interrelation between recrystallization temperature and annealing time for a certain deformation of metals is represented by formulas. EF (4c)

The mechanism of the Deformation of Wire-Drawn Tubing (Sul meccanismo di deformazione di un tubo trafilato). V. MONTORO. *La Metallurgia Italiana,* Vol. 26, May 1934, pages 331-334. The mechanism of the deformation of wire-drawn tubing having a composition: Cu 73.3 atomic %; Zn 20, and Al 6.7 atomic %; and sp. gr. of 8.33, has been investigated. The factors influencing the distribution in size and direction of the fibrous structure during wire-drawing are: the degree of reduction of the diam.; the diam. of the wire; and the angle of the lines of flow in the area of constriction. Microphotographs showing the flow lines in wire-drawn specimens are shown. AWC (4c)

Effect of Processing on the Properties, Especially Deep-Drawing, of Strip Steel (Einfluss der Herstellungsbedingungen auf die Eigenschaften, besonders die Tiefziehfähigkeit, von Bandstahl). H. KAYSELER, H. LASSEH, W. PÜNGEL & E. H. SCHULZ. *Stahl und Eisen,* Vol. 54, Sept. 27, 1934, pages 993-998. Basic open-hearth and basic Bessemer strip steels of 0.09 and 0.05% C content respectively were tested. After cold working 10 to 70% the samples were either annealed at 650° to 750° C. or normalized at 950° C. and then skin rolled. The normalized strip had higher strength but lower ductility. The deep drawability of both was about the same. The normalized strip gave fewer repeated bends. The best drawability was obtained in the strip cold worked 35% and then annealed. After skin rolling 1% flow lines or stretcher strains disappeared, but returned after aging 3 weeks; after 3% skin rolling the flow lines did not return after aging several months. SE (4c)

Properties of Differently Treated Steel Strip with Particular Consideration of Suitability for Deep-Drawing and Its Testing (Ueber von verschieden behandeltem Bandstahle mit besonderer Berücksichtigung der Tiefziehung und deren Prüfung). H. KAYSELER. *Mitteilungen aus dem Forschungs-Institut der Vereinigte Stahlwerke Aktiengesellschaft, Dortmund,* Vol. 4, Apr. 1934, pages 39-82. Investigations into the effect of preliminary and after-treatment of cold-rolled strip steel showed that 1) the temperature of intermediary annealing in the crystallization range is of no great consequence; mechanical and technological properties, in particular tensile strength and deep-drawing quality, are improved by recrystallizing annealing; 2) preliminary rolling has an effect only if the annealing temperature is below the Ac_3 point; in this case, a previous rolling of 35% produces best values of elongation and deep-drawing quality; 3) tempering of short duration increases elongation considerably without impairing tensile strength. Another result of the tests was the development of a method for determining deep-drawing quality combining the wedge-drawing and cupping tests, and a method of lubrication which reduces the influence of friction of the wedge in the test. All tests are described in detail and illustrated by curves. 81 references. Ha (4c)

Manufacture of Suspension Bridge Wire. FR. A. WESTPHAL. *Wire & Wire Products,* Vol. 9, Aug. 1934, pages 240-244, 254-255. Special care must be exercised in the manufacture, handling and testing of bridge wire as it is to carry live loads and subjected to exceptionally high and enduring stresses. Wire drawing practice, handling methods, equipment in the production of wire is described. The best steel could be obtained from crucible and electric methods but as only small quantities at a time can be melted, open-hearth steel is mostly employed; usual analysis is: 0.75-0.85% C, 0.5-0.7% Mn, 0.1-0.2% Si, 0.04% (max.) P, 0.04% (max.) S, 0.15-0.25% Cu. Proper heat-treatment of ingots is of prime importance. Ha (4c)

Machine for Bending Pipe Coils. CHAS. C. TOMNEY. *Machinery,* N. Y. Vol. 40, Aug. 1934, pages 742-743. Describes a machine to make smooth, short radius bends without requiring the pipe to be heated or filled with sand. Ha (4c)

Lubrication for Drawing Copper Wire. JOHN G. RICHARDS. *Wire & Wire Products,* Vol. 9, Sept. 1934, pages 338-339, 355. The importance of correct selection of lubricant for Cu wire drawing is pointed out. As water-cooling is necessary, water emulsions of fats are usually employed. The types of fats available and their characteristics are discussed. Ha (4c)

Wire Drawing at the Higher Speeds. J. B. NEALEY. *Wire & Wire Products,* Vol. 9, July 1934, pages 213-215. Modern drawing machines of high speed for fine wires with a multiple die system as used by the Belden Manuf. Co. are described. Ha (4c)

Lime Coating of Rods vs.—What? HAROLD G. HOBBS. *Wire & Wire Products,* Vol. 9, Sept. 1934, pages 311-314. Experiments were carried out with silicate of soda and trisodium phosphate as substitute for lime in coating of wire rods prior to drawing. No definite advantages could as yet be stated. Ha (4c)

Combination Press Tools That Save an Operation. J. J. MCHENRY. *American Machinist,* Vol. 78, Aug. 1, 1934, pages 534-535. Describes a tool for producing bent and notched parts. Ha (4c)

Stretching and Packing Fourdrinier Wires. KURT JAHN. *Wire & Wire Products,* Vol. 9, Aug. 1934, pages 245, 258. Equipment and handling are described. Ha (4c)

The Technology of Stamping (Zur Technologie des Stanzens). K. M. DOLEZALEK. *Zeitschrift Verein deutscher Ingenieure,* Vol. 78, July 21, 1934, pages 871-874. Measuring arrangements are described to determine curves of direction and magnitude of pressure exerted in stamping and punching processes; oscillograms proved to be particularly valuable for analysis of such working methods. It can be seen that the die remains stationary as soon as it hits the material to be punched and the press is deformed (torsion of shafts, springing action of housing, etc.). Only when the highest pressure is reached does the die proceed on its way and push the punched-out part before it. Ha (4c)

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The Modern Coppersmith. L. A. Voss. Edwin A. Scott Publishing Co., Inc., New York, 1934. Fabrikoid, 5 x 7¼ inches, 375 pages. Price $5.00. The products of the coppersmith are in so many cases tailored to order, rather than duplicated in quantity, that the craft is essentially one of hand tools and methods. The technique of forming and joining copper is described in detail and by many illustrations ranging from very simple to highly complex. Aluminum, nickel and Monel are also briefly dealt with.

The shop kinks are given clearly and should be helpful. Not much metallurgy is included, indeed it is stated that expansion and contraction of a copper pipe brazed to a steel flange will "crystallize" the copper. It should be of value to the sheet metal worker and of interest to the copper metallurgist.

H. W. Gillett. (4c) —B—

Machining (4d)

H. W. GRAHAM, SECTION EDITOR

Cutting Test of High-speed Steels of Home and Foreign Make. Masakuni Sugimoto & Kenta Fukuda. *Tetsu to Hagane,* Vol. 20, Mar. 25, 1934, pages 176-183. (In Japanese.) Cutting test was carried out using 35 high speed steels of different compositions under respective heat-treatments directed by the manufacturer, resulting in marked difference in tool life not only by composition but also in steels of nearly equal composition. The difference in tool life between superior and inferior steels is also found in tests at different cutting conditions, with different materials to be cut, and in steels of same class but manufactured at different charges. This is confirmed by the measurements of the rise of temperature, behavior of abrasion of end of blade, thermal conductivity, cutting pressure and hot hardness, and examination of microstructure; size of carbide particles is fine in superior steel, while coarse in inferior steel, and it is slightly improved by devising modes of forging and heat-treatment. From these results it is concluded that the difference in cutting performance is due to quality of steel, which is primarily influenced by methods of manufacture, i.e., manufacturing technique and charge material, and secondarily by modes of forging and heat-treatment. ST (4d)

Durability of Twist Drills Machining Cast Iron. G. Varley. *Engineer,* Vol. 158, Aug. 17, 1934, page 160. Tests were made using twist drills of standard 18% W high-speed steel on cast iron of various Brinell hardnesses. Equations are given to work out the relationship of drill durability in this type of cutting with that obtained by Taylor and later investigators for lathe tools cutting steel. Tables and graphs are given showing the results of these tests. LFM (4d)

A Few Experiments on High-Speed Turning. Taketarô Madsuda & Katsuzô Kurokawa. *Journal Society of Mechanical Engineers,* Vol. 37, Feb. 1934, pages 55-59. In Japanese. Paper read at the Nagoya Local Meeting of the Society of Mechanical Engineers, Sept. 16, 1933. The authors turned various metals on a "super-high speed" lathe using cemented carbide cutting tools. The finished surfaces obtained were of very high quality. The question is discussed whether high-speed lathes and cemented carbide tools can expel the grinding machine from the machine shop. The authors agree that to some extent they may do so. Kz (4d)

Modern Machining Methods of Vehicle Motors (Die moderne Fahrzeugmotor-Bearbeitung). Otto Lich. *Automobiltechnische Zeitschrift,* Vol. 37, July 25, 1934, pages 373-379. Arrangements, tools, jigs, clamping devices, etc. are described and illustrated. Ha (4d)

On the Wear of Lathe Tool in Light Cut. Ei-iti Sasaki. *Journal Society of Mechanical Engineers,* Vol. 37, Apr. 1934, pages 206-210. In Japanese. Paper read before the 10th General Meeting of the Society of Mechanical Engineers, Apr. 7, 1933. After dealing with Taylors' formula giving the relation between cutting speed and durability of the cutting tool, the author draws the following conclusion from his own tests. Taylors' formula does not hold good in the range of light cut. When the cutting speed increases or when the area of cut increases, the durability of the tool approaches the Taylor formula. Kz (4d)

Remodeling of Used Machine Tools for Increasing Capacity (Leistungssteigernder Umbau gebrauchter Werkzeugmaschinen). Alf Schroeder. *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, Aug. 19, 1934, pages 522-523. Paper describes and shows a number of interesting instances in which obsolete machine tools were efficiently remodeled. GN (4d)

Developments in Metal-cutting Technique and their Practical Application. M. Kronenberg. *Machinery,* London, Vol. 44, June 7, 1934, pages 277-280. The limits of cutting speed values, given in engineers' handbooks, are so wide that they do not permit accurate calculation. Discrepancies resulting from the selection of figures from three handbooks are illustrated. The author gives a formula which is sufficiently accurate and simple to apply. Values depending on the material to be cut and which have to be substituted in the formula are given in tables. Dealing with cutting pressure, factors influencing its value are pointed out and a formula and tables are given to allow the calculation of the cutting pressure. The machining time for a given piece can be calculated with the help of a formula presented. The formulae for cutting speed and cutting pressure may be employed for determination of the maximum machine-tool output capacity. In general tool-life is greater when turning with small feeds and large depths of cut than for the inverse case, but the output in in.^{2}/min. remains unchanged if the machine is fully utilized. Utilization is limited by the highest permissible cutting pressure allowed by the machine design, by the possibility of obtaining the desired r.p.m. and by the tool. Advantages to be derived from the use of tungsten-carbide tools are high-speed and an increase of the cross-section area of chip if the machine will stand the increased cutting pressure and if the utilization-limit cannot be reached with high-speed steel tools. Kz (4d)

Cutting Fluids. *Automobile Engineer,* Vol. 24, Oct. 1934, page 370. Nature and testing methods of cutting lubricants, and selection of proper oils according to the required purpose is discussed. Ha (4d)

The Production of Valves, Steam and Water Fittings. *Machinery,* London, Vol. 44, Apr. 19, 1934, pages [illegible]1-67. Majority of the castings are machine-molded from either gun-metal or white-metal patterns. Gun-metal patterns are used for quantity production; white-metal patterns, when quantities required do not exceed 500. Patterns are [illegible]te-mounted and in the case of the white-metal type the metal forming the pattern and also the centre part of the pattern plate is cast into an Al frame. Dealing with core production, core-box vise, core-blowing machine and hot-air heated core baking oven are discussed. To remove cores from brass and gun-metal castings the hot pieces are dipped in a tank of water, causing steam to generate inside the casting and the accumulated pressure thus set up ejects the core sand. Discussion of machining operations and machine tools used. Kz (4d)

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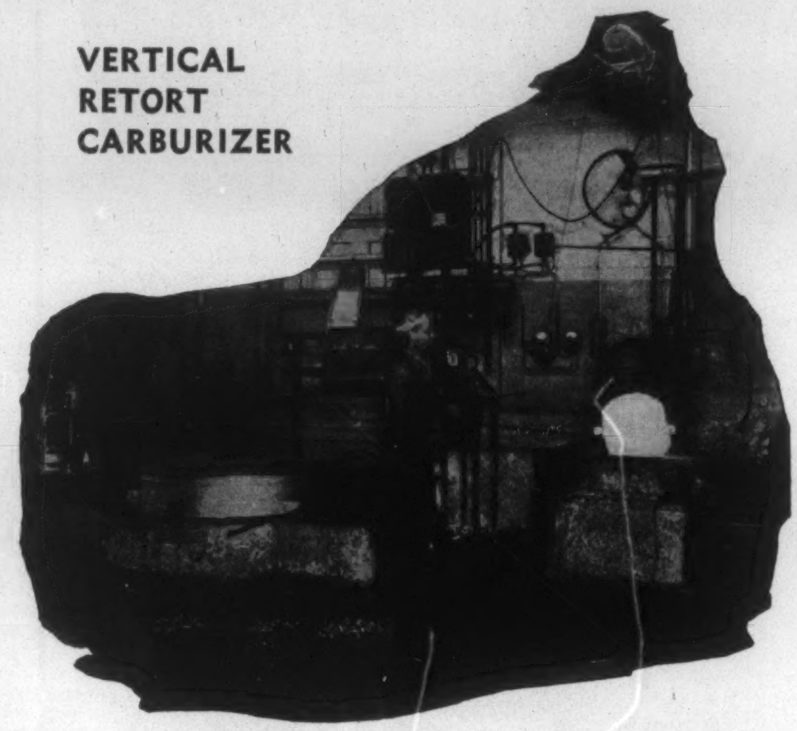

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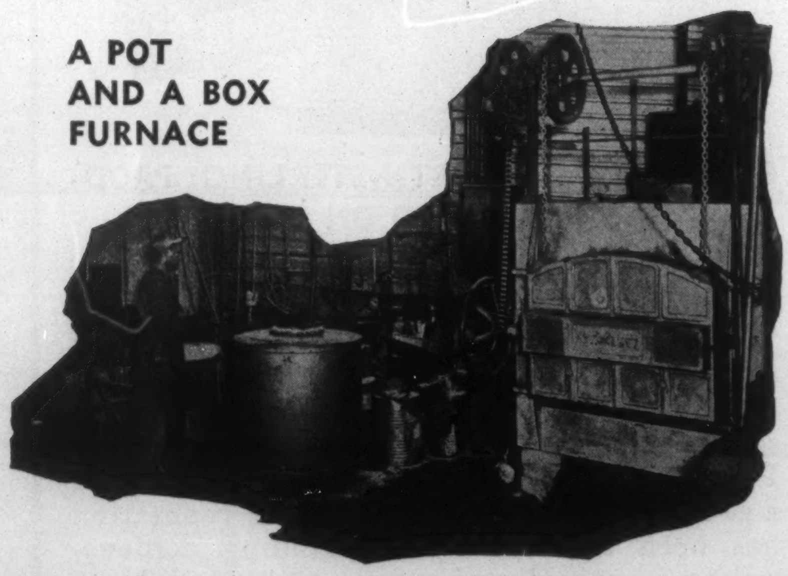

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HEAT TREATMENT (5)

O. E. HARDER, SECTION EDITOR

Annealing with a Lavite Furnace. A. E. BELLIS. *Wire & Wire Products,* Vol. 9, Oct. 1934, pages 376-378, 385. The Lavite furnace is so constructed that heat can be stored in order to use electric energy only in the off hours in the shop. An example of heating wires in batches of 900-1200 lbs. in the Lavite bath to 1200°-1350° F. is described; the saving in electric energy as compared with other fuel-fired furnaces was considerable. Ha (5)

Review of Heat Treating and Finishing. C. R. AUSTIN. *Metal Progress,* Vol. 26, Oct. 1934, pages 99-105. Various heat treatments are discussed under headings of bright anneal, carburizing with gas, liquid and solid agents, nitriding and heat treatment of tool steel. Quenching methods are discussed especially in light of references to work on heat transfer in quenching and "hot quenching" to eliminate cracks in hardened steel. Cleaning methods for removal of scale and machine or quenching oil and slushing and rust preventive measures are described briefly. WLC (5)

Temperature Measuring and Control Equipment. *Metal Progress,* Vol. 26, Oct. 1934, pages 117-122, 128. Sensitivity and range of usefulness of various types of thermometers and thermocouples are described and their suitability for actuating control devices discussed. The uses of optical and radiation pyrometers are described. Recording and control equipment to be operated from various temperature measuring instruments is described including instruments effecting a multi-point control and their applications discussed. Program control for a predetermined treatment cycle is described. WLC (5)

Hardening, Quenching & Drawing (5b)

The Problem of Quenching Media for the Hardening of Steels. HOWARD SCOTT. Paper presented at annual meeting of *American Society of Mechanical Engineers,* New York, Dec. 4-9, 1933; *Iron Age,* Vol. 132, Dec. 14, 1933, page 21; *Heat Treating & Forging,* Vol. 20, Feb. 1934, pages 88-89. The necessary cooling rate, in excess of a well-defined critical value characteristic of particular steel composition, varies greatly across a section, so that hardening is sometimes incomplete in large parts. Where surface hardening alone is adequate, a plain carbon steel may be used and the most active quench attainable appears best if steel composition is properly controlled. Where machine parts are required to have the same high mechanical strength throughout, alloy steels are used to obtain complete hardening in larger sizes than possible with carbon steels. The fastest practicable quench would then permit use of minimum alloy content favorable to machinability but it introduces extremely high temperature gradients with excessive distortion and danger of cracking in complicated shapes. Quenching medium selected must therefore afford a compromise between economies of low alloy content and penalties of distortion. Best compromise appears to be attained in media which provide a high cooling rate within the steel from 600 to 500°C and a very low cooling rate below 400°C. This minimizes both distortion and residual stresses which cause quenching cracks. Control of cooling rates below 400°C is more important the higher the carbon content. There are critical sizes with respect to cracking for each composition of steel and quenching bath. They are best avoided by slow cooling through the hardening transformation which usually occurs below 400°C. Cooling usually progresses in 3 well-defined stages. The first, vapor cooling, is slow. Vapor film breaks down abruptly when metal surface reaches a temperature which is characteristic of the liquid chiefly. In second stage, cooling by vapor-liquid convection, rate of heat transfer from metal to bath is highest. Finally, as surface temperature of metal approaches boiling point of bath, boiling ceases, so cooling in third stage is by conduction and convection. First stage is most prominent in liquids of low and sharp boiling point, is not conspicuous in good quenching oils, is a dominant factor in water quenches. Slow cooling cannot be tolerated during early stages of a quench, must be prevented from occurring in practice. Agitation of liquid is effective in avoiding formation of vapor blanket; the solution of inorganic salts in water is helpful when active agitation is not practicable. It is more conspicuous the higher the bath temperature; hence the general practice of keeping quenching baths of low boiling point as cold as is feasible. Second stage of surface cooling is dominant one in hardening of steel. Cooling powers of liquids when cooling by vapor-liquid convection differ considerably. Water and concentrated H_2SO_4 appear to be effective liquids. With a well-agitated water quench, cooling rates are obtainable at some depth in the steel which closely approach the maximum theoretically attainable value determined by thermal constants of the steel. Oils are less active in this stage than water. Low-viscosity oils are superior to high in this regard. Apparently viscosity is a major factor in determining the cooling power of a liquid. Cooling in the third stage is relatively slow for all liquids; change in cooling rate from second to third stage is particularly large in oils and is valuable characteristic. It is enhanced by raising oil temperature without sacrifice of cooling power at high temperatures. The same characteristic might be of value if obtained in water quenches, but no simple composition variation appears favorable thereto. MS + VSP + MFB (5b)

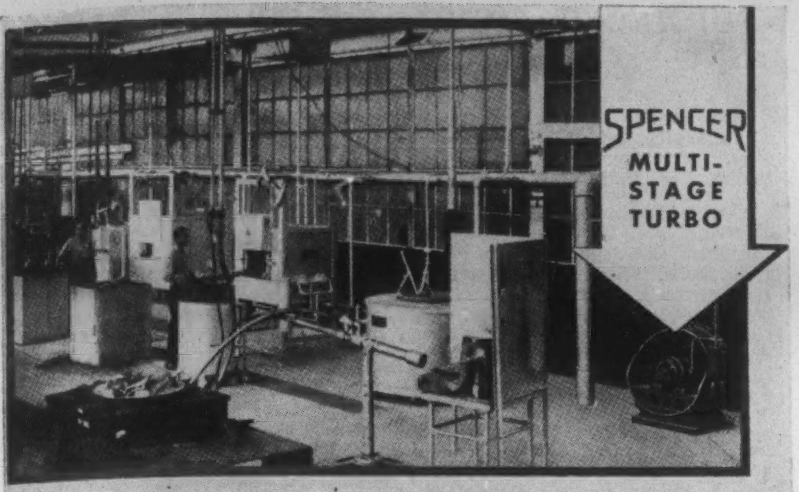
The Influence of the Critical Cooling Rate on Hardening of Steel. J. W. SANDS. *Industrial Heating,* Oct. 1934, pages 21-23. Difficulties in obtaining a proper cooling rate which abstracts heat sufficiently fast to hold the austenite existing at high temperatures before quenching at its first decomposition stage, martensite, are explained. The critical cooling rate is not constant for a given steel during quenching; low critical cooling rates are desirable as they reduce internal stresses and give better hardening in larger sections. The characteristics of various coolants, effect of section, influence of composition of the steel are discussed. Ha (5b)

Heat-Treatment of Springs for "Knee Action" Mechanism. J. B. NEALEY. *Industrial Heating,* Nov. 1934, pages 105-110. Manufacture and method of and furnaces for heat-treatment of coiled springs are described; the springs are hardened, tempered and finished with 2 coats of baked enamel. Ha (5b)

Surface Hardening of Pins for Joints to improve the Action and Wear of Bushings. (L'Indurimento superficiale dei perni degli alberi a gomito per migliorare il comportamento e la durata dei cuscinetti). V. S. PREVER. *La Metallurgia Italiana,* Vol. 26, Aug. 1934, pages 600-612. Pins may be surface-hardened by heating locally with an oxyacetylene flame, then hardening and tempering. Three types of steels treated in this way are shown as follows:

	C	Ni	Cr	W	Si	Mn	S	P
a)	0.38	4.25	1.15	0.60	0.25	0.50	0.030	0.025
b)	0.34	2.25	0.70		0.30	0.55	0.035	0.039
c)	0.43				0.35	0.70	0.040	0.038

They were heat treated as follows: a) oil-hardened at 800°C., and tempered at 640°C. for 30 minutes; b) oil-hardened at 810°, tempered at 575° for 30 minutes; c) hardened in water at 810°, tempered at 575° for 30 minutes. This gives pins having high surface hardness, making it possible to use bronze rather than white metal bushings, with resulting increased wear resistance. AWC (5b)



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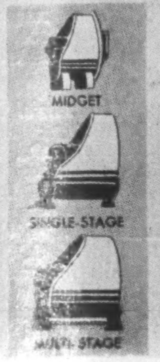

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Improved Hardening Through Furnace Atmosphere Control. James E. Hines. *Industrial Heating*, Oct. 1934, pages 24-28, 34. The reasons for and subsequent development of control of the atmosphere of hardening furnaces are explained, and recent constructions in gas and electric furnaces for obtaining the desired end are described. Ha (5b)

The "Shorter" Process for Surface Hardening. *Engineering*, Vol. 138, Sept. 28, 1934, page 337. From a report of an investigation carried out under T. Swinden, at The United Steel Companies, Ltd., Stocksbridge, England. The following steels were tested: 0.46% C, Cr, Mn-Mo, Ni-Cr, Cr-Mo, 3½% Ni and Ni-Cr-Mo. The C in the alloy steels ranged 0.42-0.32%. It was found that in these steels subjected to the Shorter process of surface hardening, the actual degree of hardness obtained on the surface is entirely dependent on the C content of the steel. The difference in results between a C steel and an alloy steel is slight and the differences among the various alloy steels are insignificant in their response to the treatment. LFM (5b)

Change in Magnetic Saturation on Tempering Quenched Carbon Steels (Die Aenderung der magnetischen Sättigung beim Anlassen abgeschreckter unlegierter Stähle). H. Esser & G. Momm. *Archiv für das Eisenhüttenwesen*, Vol. 8, Oct. 1934, pages 177-180. The quenched samples were inserted in the magnetic apparatus described by Stablein and Schroeter and tempered in vacuo, the changes in magnetic saturation being continually measured. Fe-C alloys made from carbonyl Fe and C and crucible steels of 0.4 to 1.7% C and a steel with 2% C and 2% Mn were tempered after water quenching from the γ region. The magnetic saturation of cementite was assumed to depend on the particle size, the cementite only being magnetically evident on tempering above 250°C. The results indicated that austenite breakdown may begin at 130°C., increasing rapidly with rising temperature. SE (5b)

Effect of Tempering on the Quenching Stresses in Steel (Einfluss des Anlassens auf die Abschreckspannungen bei Stahl). H. Bühler & H. Buchholtz. *Archiv für das Eisenhüttenwesen*, Vol. 8, Sept. 1934, pages 117-119. Internal stress measurements in various structural steels were made after quenching from below A_1 and tempering at 300°C. The quenching stresses were equalized in 50 mm. diameter cylinders after 10 hrs., and in larger cylinders after 20 hrs. On tempering in the blue heat region the stresses remaining after tempering depended on the original quenching stresses. On approaching the recrystallization temperature this was no longer so, and on tempering above 550°C. even high quenching stresses were entirely removed. SE (5b)

High Lights on the Tempering and Straightening of Tool Steels. Wm. C. Betz. *Modern Machine Shop*, Vol. 7, Oct. 1934, pages 28-34. The nature of heat-treating, modern processes in hardening and tempering, and means to avoid deformation of large pieces in the process are discussed. Ha (5b)

Combustion Atmosphere and Scaling Steel. J. A. Stein. *Industrial Heating*, Dec. 1934, pages 169-174. The scaling effect of combustion atmospheres, the economical effect of atmosphere control and equipment for measuring the atmosphere are discussed. In general, scaling losses increase with increasing temperature, time, and with increasing ratio of H/C in the fuel which conditions make accurate knowledge and control of the atmosphere advisable. Apparatus and operation are described. Ha (5b)

Improved Hardening of Stainless Steel Parts. James I. Hines. *Industrial Heating*, Dec. 1934, pages 181-184. Improvements in heat-treating tool steels by controlling the furnace atmosphere in a definite manner suitably adapted for the respective purpose are illustrated by the example of hardened valves. Ha (5b)

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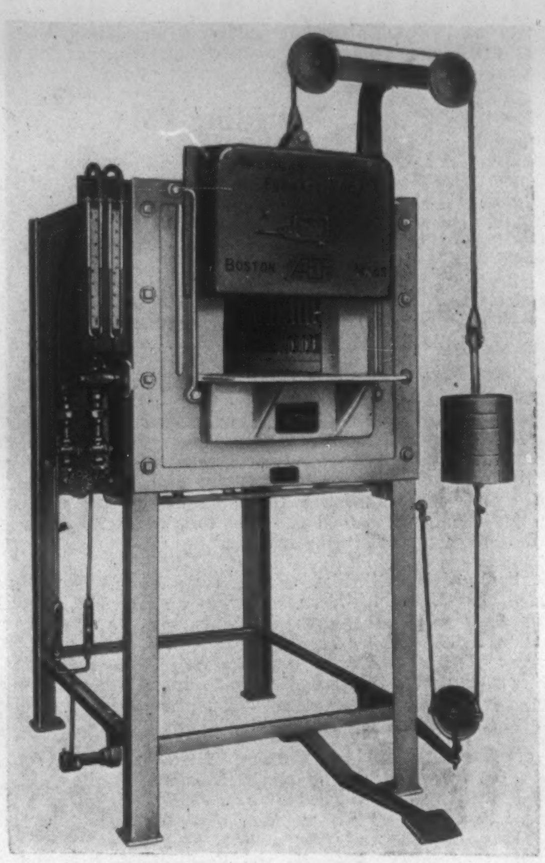

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Carburizing (5e)

Various Methods of Carburizing. E. F. DAVIS. *Industrial Heating,* Oct. 1934, pages 31-34. Developments in carburizing compounds and carburizing boxes are discussed, and cementation processes and function of energizers in stimulating the flow of the carburizing gas explained. Charcoal is still the ideal agent for carburizing as it supplies pure C whilst coke and other agents develop detrimental S. Boxes are now made usually of alloys of 60-65% Ni and 12-16% Cr. Ha (5e)

Recent Advances in Carburizing Steel (Les récents progrès de la cementation des aciers par le carbone). L. GUILLET. *Génie Civil,* Vol. 104, Jan. 6, 1934, pages 7-12; Jan. 13, 1934, pages 29-36; Jan. 20, 1934, pages 58-62; Jan. 27, 1934, pages 82-85. Comprehensive survey of the latest developments. Industrial equipment, carburizing compounds, economic aspects, theories and defects of carburization are fully discussed. JDG (5e)

Nitriding (5f)

Nitricastiron. V. O. HOMERBERG & D. L. EDLUND. *Metals & Alloys,* Vol. 5, July 1934, pages 141-144. Development of a nitridable cast iron of total C 2.50%, Si 1.50%, Mn 0.60%, Mo 0.60%, Al 1.25%, Cr 0.20% for use as cylinder liners and cams after nitriding to give hard surface. Such cast iron can be readily machined and shows good properties in the "as cast" or heat treated condition. WLC (5f)

Accelerators for Nitriding (Nitrierhärtungsbeschleuniger). H. KALPERS. *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, June 3, 1934, pages 351-352. Among the various methods of accelerating the speed of nitriding are discussed (1) influencing the gas atmosphere, (2) presence of metallic bodies, (3) presence of halogens, (4) presence of N-bearing organic compounds. The first mentioned method refers to the method of the Electro Metallurgical Company, New York, using nitrogen oxides in conjunction with the common nitrifiers. (2) According to investigations of the same company both Fe and non-ferrous metals can successfully be applied as accelerators. (3) According to a patent of the Krupp Works even small amounts of halogens either of elementary or compound character are sufficient to attain acceleration of the nitriding process. (4) The last mentioned method patented to the Electro Metallurgical Co. applies compounds containing several NO_2 radicals. GN (5f)

Specific Heats of Iron Nitrides. SHUN-ICHI SATO. *Bulletin of the Institute of Physical & Chemical Research, Tokyo,* Vol. 13, July 1934, pages 716-719. (In Japanese.) *Abstracts & Scientific Papers of the Institute of Physical & Chemical Research, Tokyo,* Vol. 13, July 1934, pages 40-41. (In English.) The mean specific heats between 0° and 100°C. of nitrided Fe of various N contents were determined with an ice calorimeter. The curve correlating N content/specific heat exhibits a maximum and yielded the following heat values: 0.1242 for Fe_4N and 0.1343 for Fe_2N. WH (5f)

Heats of Formation of Iron Nitrides. SHUN-ICHI SATO. *Bulletin of the Institute of Physical & Chemical Research, Tokyo,* Vol. 13, July 1934, pages 720-724. (In Japanese.) *Abstracts & Scientific Papers of the Institute of Physical & Chemical Research, Tokyo,* Vol. 24, July 1934, page 41. (In English.) Using the observed specific heats of Fe_4N and Fe_2N and equilibria data of the systems Fe, Fe_4N, NH_3, H_2 and Fe_4N, Fe_2N, NH_3 and H_2, the formation heats of Fe_4N and Fe_2N were calculated with the aid of the Nernst heat theorem. The calculated values agree well with the formation heats of Fe_4N and Fe_2N as determined with a calorimeter. WH (5f)

FURNACES, REFRACTORIES & FUELS (6)

M. H. MAWHINNEY, SECTION EDITOR

Heat-Transfer in Non-Ferrous Metals in Reheating Furnaces. G. WAGENER. *Metallurgia,* Vol. 10, Aug. 1934, pages 112-116. Abridged translation from *Zeitschrift für Metallkunde,* Feb. 1932, page 35. See *Metals & Alloys,* Vol. 3, Dec. 1932, page MA 358. JLG (6)

Electric Furnaces for Process Heating. C. H. S. TUPHOLME. *Chemical Industries,* Vol. 35, Aug. 1934, pages 127-128. Electrically heated boilers for generation of steam or for hot water can often be advantageously used in industrial plants, where fuel is expensive or electric power purchased on an annual contract basis, according to this review of recent European progress. Resistance heating coils are used for small loads and for direct current. For loads above about 10 K. W., 500 — 16,000 volts a.c. can be used directly by the electrode system, the boiler itself acting as a resistance. Electric boilers are especially adapted for automatic control, as for making distilled water. An installation with steam accumulator is illustrated. BWG (6)

Cathode Ray Furnace (Four à rayons cathodiques). FÉLIX TROMBE. *Bulletins de la société chimique de France,* Vol. 5, Feb. 1934, pages 262-266. Reviews previous contributions and introduces a cathode ray furnace connected with a 110-20,000 volt transformer, operating at 100 m. amps, and attaining a maximum temperature of 3400°C. in 15 or 20 seconds. EF (6)

Fifteen Years of the Heat Engineering of Open-Hearth Furnaces. W. TRINKS. *Industrial Heating,* Oct. 1934, pages 51-54. Development in furnaces, refractories, furnace control, checker design, during the last 15 years are reviewed. Ha (6)

Heat Insulation of Open Hearth and Electric Steel Furnaces (Värmeisolation av martin-och elektrostalugnår). SIXTEN WOHLFAHRT & OLOF ELL. *Jernkontorets Annaler,* Vol. 118, Sept. 1934, pages 447-474. The results of plant experiments on 2 open hearth and 2 electric furnaces indicate that the bottom is that portion of the hearth which it is most economical to insulate. The life is increased, fuel and energy requirements decreased by 10% and the production increased by 13%. HCD (6)

Furnaces Which Are Shipped Complete with Brickwork (Oefen, die ausgemauert versandt werden). SCHUMANN. *Elektrowärme,* Vol. 4, Oct. 1934, pages 221-223. Construction of portable furnaces up to 120Kw capacity is described. Ha (6)

Trend of Brass Mill Annealing Practice. P. E. PETERSEN. *Industrial Heating,* Oct. 1934, pages 13-18. The various fuels used, the particularly good effect of wood fire which even now is still used for good results in obtaining bright surfaces; control of atmosphere in electric and gas-fired furnaces; and recuperative furnaces are discussed. Ha (6)

Induction Heating with Normal Low Frequency in Chemical Industries (Induktionsheizung mit normaler Niederfrequenz in der chemischen Industrie). O. NEISS. *Siemens-Zeitschrift,* Vol. 14, May 1934, pages 175-178. Non-conductive materials can be economically heated electrically in the temperature range of 180°-1000° C. with ordinary low frequency supply by indirect methods, i.e., the container for the materials is of magnetic or electrically conductive material and is heated inductively; the containers can be of any shape, suitable for the material to be heated. Several examples of heating arrangements for metallurgical, chemical and ceramic purposes are described. Ha (6)

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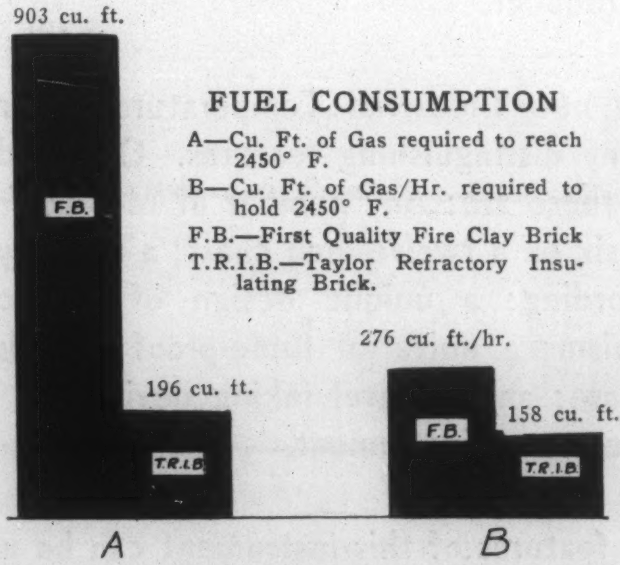

Chart drawn from data obtained on two gas-fired heat treating furnaces identical except for type of linings.

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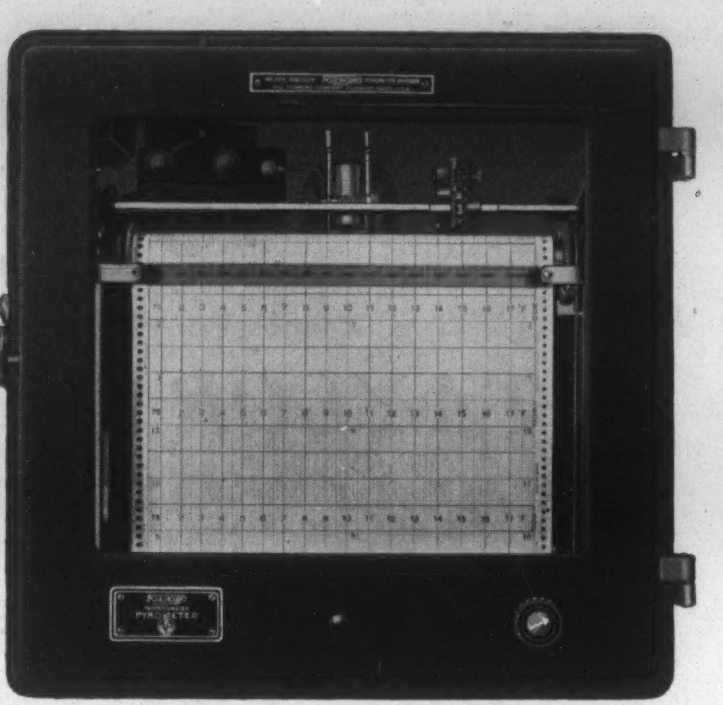

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Refractory Cements for High, Medium and Low Temperatures. W. O. LAKE. *Sands, Clays and Minerals,* Vol. 2, Aug. 1934, page 91. The different bonding materials necessary for various ranges of temperature used in industries are discussed; it is pointed out that fire clay can not form a bond below 1400° C. so that suitable cements to withstand abrasion, corrosion, chemical reaction and high temperatures had to be evolved. Ha (6)

Aluminum Alloys Aged in a Recirculating Oven. C. F. MAYER. *Industrial Heating,* Oct. 1934, pages 69-71. Construction and operating details for a direct gas-fired furnace for heat-treatment and aging of Al alloy pistons are described. Ha (6)

The Utilization of Magnesian Carbonates. F. E. LATHE. *Engineering Journal,* Vol. 17, Apr. 1934, pages 184-185. Discussion. See *Metals & Alloys,* Vol. 5, Nov. 1934, page MA 522. VVK (6)

Modern Gas Producers and Open-Hearth Furnaces (Neuzeitliche Gaserzeuger und Siemens-Martin-Oefen). O. BECKMANN. *Die Giesserei,* Vol. 21, Sept. 14, 1934, pages 389-398; Sept 28, 1934, pages 412-420. Present state of development of gas producers, increase of capacity and efficiency, and methods of complete automatic operation are discussed. The use of gas producers in connection with open-hearth furnaces, instruments and control for operation and supervision are described and illustrated by examples of most modern installations. See also *Metals & Alloys,* Vol. 4, Oct. 1933, page MA 333. Ha (6)

Heat Treatment of Steel Tools in Oil and Metal Baths (Zur Wärmebehandlung von Stahlwerkzeugen in öl- und Metallbädern). WILH. HERRMANN. *Die Metallbörse,* Vol. 24, July 14, 1934, pages 890-891. Oil baths furnish but a narrow temperature range. It is doubted that even the best grades withstand long service runs at 250°C. Oil baths are less expensive. Tools must be degreased before heat-treatment. Protection tubes of heating coils are quickly covered with hard crusts. Use of oil baths is steadily decreasing. Pb baths melt at 327° and slightly fume at 650°. Temperatures of 900° and higher can be utilized if a hood is employed. Freedom from S and Sn must be observed. The former directly affects steel, the latter causes Pb to adhere to the work. Pb baths must be covered with charcoal or coke. Frequent removal of the Pb oxide and charcoal, and occasional purification with NaOH is recommended. Dipping into molten NaOH or Na nitrite followed by water quenching cleans the steel tool after heat treatment. In lieu of charcoal, chloride or carbonate mixtures also offer a protective cover; they reduce volatilization losses and can be washed off the work. Bi-Pb-Sn bath compositions and their melting points (94°-178° C.) are tabulated. EF (6)

Yield of a Coke Gas Producer (Vergasungsleistungen von Drehrostgaserzeugern bei Vergasung von Koks). F. W. HERBORDT. *Stahl und Eisen,* Vol. 54, Sept. 27, 1934, pages 999-1000. Data are given showing how high ash content or granulation of the coke lower the yield. SE (6)

4-Ton High-Frequency Furnace at the German Alloy Steel Works in Bochum (4 t-Hochfrequenzofen bei den deutschen Edelstahlwerken in Bochum). KAUCHTSCHISCHWILI. *Siemens-Zeitschrift,* Vol. 14, Sept. 1934, pages 331-332. The most practical and economical frequency for large furnaces was found to be 500 cycles per sec. The furnace described is used to produce steels alloyed with W, Cr, Ni, V, Mo, etc. The lining can be acid or basic according to requirements and proved to be less costly than in an arc furnace. Ha (6)

Refractories and Furnace Design. A. F. GREAVES-WALKER. *Ceramic Age,* Vol. 22, Dec. 1933, page 171; *Blast Furnace and Steel Plant,* Vol. 22, Jan. 1934, page 49; Feb. 1934, page 124. Industries having refractories problems should direct their efforts to improving furnace design to meet the new requirements of their processes. Open-hearth design, for example, has been improved to a point where life of the refractories has been lengthened and furnace efficiency increased. MS (6)

Builds Improved Type Rotary Hearth Forging Furnace. *Steel,* Vol. 95, July 9, 1934, pages 26, 51. Developed by Gas Machinery Co., Cleveland, O. MS (6)

Oven for Drying Lime-Coated Rods Is Direct Fired. *Steel,* Vol. 94, June 11, 1934, page 56. Describes installation at plant of Russell, Burdsall & Ward Bolt & Nut Co., Rock Falls, Ill. MS (6)

New Furnaces Especially for Bright Annealing. *Metal Progress,* Vol. 26, Oct. 1934, pages 67-72, 84. Application of controlled mixtures of gases for bright annealing is discussed, giving references to the literature for greater detail as to compositions and methods of production and control of furnace atmosphere. WLC (6)

Insulating and High Temperature Refractories. *Metal Progress,* Vol. 26, Oct. 1934, pages 77-80. Developments in insulating refractories with some examples of results are cited. High Al_2O_3 refractories for high temperature use and high temperature patching and ramming cements are discussed. WLC (6)

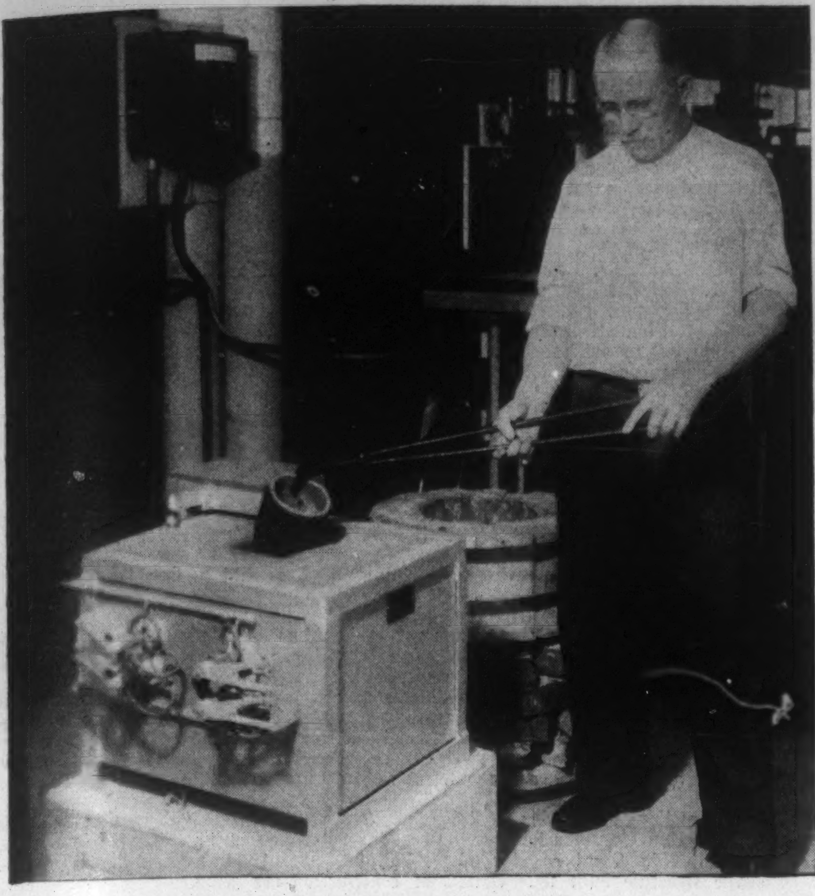
High Frequency Furnace Installation in an English Steel Works (Une installation de fours à haute fréquence dans une aciérie anglaise). *Journal du Four Electrique,* Vol. 43, June 1934, pages 212-215. Mechanical features of an installation consisting of one two-ton and one five-ton high frequency electric furnaces of Ajax-Northrup type at Samuel Fox & Co. Ltd. at Stocksbridge are described. Electrical equipment of a new type was installed by Metropolitan Vickers Electrical Co. Ltd. JDG (6)

The Sand-Preparing Plant at the Openshaw Works of Messrs Joseph Stubbs, Limited. *Foundry Trade Journal,* Vol. 49, Dec. 14, 1933, page 340. Article, accompanied by 1 diagram, describing the August composite sand-preparing plant which has recently been installed at the above works. OWE (6)

Speed Production of Unusual Super Refractory Special Shapes. E. J. BOGNAR. *Industrial Heating,* Oct. 1934, pages 59-64. Means of accelerating production of special refractory shapes in order to be able to use them more often to advantage in furnaces; control of atmosphere; and necessity of establishing firing curves for each furnace to speed production are discussed. Ha (6)

Application of Air Heaters to Multiple Oven Installations. RALPH BYRON. *Industrial Heating,* Nov. 1934, pages 138-141. The advantages of heating furnaces by air which is heated by an exterior air heater, and improvements of products due to more uniform heating by exclusion of flames or radiant heat are pointed out; a layout for an air heater serving several furnaces for temperatures up to 1000° F. is described. This is more economical than to equip each furnace with its own air heater. Ha (6)

Recent Progress in the Operation of Upper-Silesian Steel Works Gas Producers (Neuere Erfahrungen im Betriebe von oberschlesischen Stahlwerksgaserzeugern). G. DRATH & F. WESEMANN. *Archiv für das Eisenhüttenwesen,* Vol. 8, Oct. 1934, pages 151-157. A series of comparative tests in two gas producers was used to determine various influences on the yield. Only infrequently did strong baking or high ash content of the fuel reduce the efficiency. Addition of steam raised the quality and tar and H_2 content of the gas. The attempts to use finer and cheaper fuel for gas making have so far only been successful for small coal of 5-15 mm. size and for powdered coal of 3 to 10 mm. size, but such gas does not suffice for steel works use. The addition of fine coke in gas producers has also worked out in several cases. SE (6)



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JOINING (7)

Increase of Endurance Strength of Wedge Connections and Adjusting Keys (Steigerung der Dauerhaltbarkeit von Keil- und Passfederverbindungen). O. Föppl. *Automobiltechnische Zeitschrift*, Vol. 37, Oct. 10, 1934, page 512. The endurance strength of a wedge joint was found to improve 10-15% if the surface of the key slot was made denser by hammering or pressing, and the more so the harder the steel used. By giving wedge and slot proper shape the stress around the wedge can be distributed more uniformly. Ha (7)

Soldering & Brazing (7a)

C. H. CHATFIELD, SECTION EDITOR

Soldering and Tinning of Copper Sheets, Copper Steel, etc. (Soudure et Étamage des Tôles de Cuivre, Acier au Cuivre, etc.). Geo. DuBois. *Cuivre et Laiton*, Vol. 7, Sept. 30, 1934, pages 419-423. Preparation of work and practice of soldering and tinning is discussed, and composition of Pb-Sn solders for different purposes and melting temperatures are given. Literature is cited. Ha (7a)

Penetration of Brass Solder into Steel as Consequence of Hydrogen Absorption in Pickling (Das Eindringen von Messinglot in den Stahl als Folge der Wasserstoffaufnahme beim Beizen). P. Bardenheuer & H. Ploum. *Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung, Düsseldorf*, Vol. 16, No. 11, 1934, pages 137-140. It had been observed that when joining steel parts by soldering with brass, often cracks occur near the joint which must be ascribed to penetration of the soldering material into the steel. An exhaustive study showed that the structural cohesion of a low C steel can be disturbed by H absorbed in previous processes or treatments to such degree that the solder penetrates in the intercrystalline cracks which lowers the mechanical resistance against action of interior stresses. Ha (7a)

Welding & Cutting (7b)

C. A. McCUNE, SECTION EDITOR

Procedure Handbook of Arc Welding Design and Practice. Lincoln Electric Company, Cleveland, Ohio, 1934. Enlarged Edition. Fabrikoid, 6¼ x 9¼ inches, 454 pages. Price $1.50.

The new volume is greatly enlarged and encyclopedic in scope and contents. It contains over 450 pages with several hundred illustrations. The eight principal sections deal with various phases of arc welding in a simple, concise manner, well illustrated with detailed drawings and photographs. Taken together, they cover practically every use and application of arc welding.

Among the many additional features which have been included in the new edition are the following: weld inspection (visual, stethoscopic, electro-magnetic, X-ray and gamma ray); study of stress distribution by means of polarized light; a simplified method for the design of arc welded machinery; procedure and speeds for arc welding aluminum; technique and speeds for welding of copper; construction of welded water lines, etc.

Aside from the value of the book as a practical guide to anyone interested in welding, it serves as handy reference work for estimators. Complete welding speed tables and information make it a simple matter to estimate welding costs.

Richard Rimbach (7b) -B-

Arc Welding for Bridge Construction in Sweden (Vlambooglaschen bij bruggen bouw in Zweden). *Polytechnisch Weekblad*, Vol. 28, Mar. 15, 1934, page 174. Data are presented on the Traneberg and Pålsund bridges recently constructed by arc welding in Sweden. WH (7b)

Safe Welding Repair of Crude Oil Pipe Line. *Oil Weekly*, Vol. 73, Apr. 2, 1934, pages 26-28. Welding on an 8″ crude oil line is critically discussed because of an accident which happened during the repair work. Kz (7b)

Advances in Oxy-Acetylene Welding. *Metal Progress*, Vol. 26, Oct. 1934, pages 139-142. Diagrams show the technique of handling rod and flame a neutral or excess acetylene flame. Properties of such weld metal and applications of these methods are discussed. Application of hard wear resisting surfaces by welding is described. WLC (7b)

An Arc-welded Railway Viaduct. *Electrical Review*, Vol. 114, June 15, 1934, page 864. Sharnbrook viaduct of the London, Midland and Scottish Railway was repaired and strengthened by welding about 140 tons of new steelwork into position. Welding amounted to about 22,000 linear ft. MS (7b)

Improved Arc Welding Equipment and Electrodes. *Metal Progress*, Vol. 26, Oct. 1934, pages 143-146, 148. Improvements in arc welding equipment and handling accessories to make operations automatic or partially so and speed up adjustment of work are described. Great improvement in weld metal has been obtained by suitable coatings which have been developed for metals supplied in form of welding rod including stainless alloys. Cleanliness, uniformity and physical properties are all improved by proper flux applied to rod as a coating. WLC (7b)

Specifications for Welded Steel Structures (Vorschriften für geschweisste Stahlbauten). *Autogene Metallbearbeitung*, Vol. 27, Sept. 1, 1934, pages 283-285. The new German DIN 4100 specifications of 1934 for materials, procedures, calculation of seams, permissible stresses, testing, inspection, and supervision of welders are reprinted and commented on. Ha (7b)

Pipe For Light Structures. *Oxy-Acetylene Tips*, Vol. 13, Oct. 1934, pages 221-227. Design principles for using pipes, especially secondhand pipe, as structural material are discussed, economical advantages pointed out and welding procedures and inspection methods described. Ha (7b)

The Development of the Arc Welded Rail Joint (Die Entwicklung des bogengeschweissten Schienenstosses). *Zeitschrift für Lichtbogenschweissung*, Vol. 11, Aug. 1934, pages 1081-1090. Paper reviews the development of the arc welded rail joint and discusses results of fatigue tests on various types of joints. Fatigue tests were performed on an Amsler fatigue testing machine with common rails weighing 45 kg./m. and 32 kg./m. respectively. There were tested rail joints provided (1) with foot plate, (2) with cheek clamps and (3) joints with cheek clamps and trapezoid like foot plate and (4) butt joint. The principal results are: Joint (1) shows mediocre fatigue properties probably due to local stresses set up on welding. Furthermore this type of joint shows a very non-uniform stress distribution which may cause a low fatigue limit. Joint (2) gives better stress distribution and, therefore, also better fatigue properties. Still better results were attained in using a trapezoid-like stay plate. The latter joint is better able to endure complex static and dynamic loads, however, it no longer possesses the flexibility of the 2 first mentioned types of joints. The ideal solution of the welded rail joint is the butt welded joint. For attaining good durability of this joint the quality of the welding material is highly important. GN (7b)

Use of Welding in Repairs (L'Emploi de la Soudo-Brasure dans la Réparation). H. Gerbeaux. *Revue de la Soudure Autogène*, Vol. 26, Mar. 1934, pages 6-8. Despite fact that fusion welding is still largely used in repair of cast Fe, welding by using a brass as added metal is more and more used and shows advantages: Repair is quickly made very often without taking the machine apart, it is cheap and can be made with little equipment, it is possible to reinforce any spot as desired. This process needs little practice for the operator whereas, on the contrary, fusion welding requires skillful operators. Furthermore this process does not affect high strength cast Fe. A disadvantage of the process is that it leaves a very apparent trace of seam. FR (7b)

Problems of Arc Welding of Steel (Probleme der Lichtbogenschweissung von Stahl). A. Fry. *Technische Mitteilungen Krupp*, Vol. 2, Mar. 1934, pages 33-42. Discusses the static and dynamic strength of arc welds, correlating these with radiographs, microstructure and type of weld; internal stresses in welds and the cold deformation of welds; the corrosion of welds, particularly in boilers and in ship construction; and properties obtained by heat treatment involving quenching of welds. MG (7b)

Welded Road Bridges (Geschweisste Strassenbrücken). Franz Faltus. *Arcos, Zeitschrift für Lichtbogenschweissung*, Vol. 11, Aug. 1934, pages 1091-1095. Author gives a survey of the most remarkable all welded bridges built in Europe in recent years. GN (7b)

Passenger Coaches Built by Arc-Welding. *Welding Engineer*, Vol. 19, Oct. 1934, pages 27-28; *Sheet Metal Worker*, Vol. 25, Oct. 1934, pages 370-371. Construction and welding details of new arc-welded stream-line passenger coaches are described; a saving in weight of 35% is said to have been possible. Ha (7b)

Fusion Welding—Welding Tools and Machines (La Soudure Autogène—Le Matériel de Soudure). *La Technique Moderne*, Vol. 26, June 15, 1934, pages 422-429. Descriptive article reviewing recent progress in fusion welding. Article first deals with gas welding and new automatic welding machines for this type of welding, it then discusses gas cutting and fabrication of welded-structures such as machine bases and frames. Repair work made possible by welding is explained. Arc welding machines are described and the last part of the article gives a description of the latest research work on welding. FR (7b)

Construction by Fusion Welding of Overhead Bridges for Luminous Signals (Construction par Soudure Autogène de Passerelles pour Signaux Lumineux). *Revue de la Soudure Autogène*, Vol. 26, Apr. 1934, pages 2-3. Illustration of the structure built up. Details of construction are given. FR (7b)

Oxy-Acetylene Welding in Artistic Iron Works (La Soudure Oxy-Acetylenique dans la Serrurerie d'Art). *Revue de la Soudure Autogène*, Vol. 26, Mar. 1934, page 8. It is explained that the process finds more and more applications in this field one of which is illustrated. FR (7b)

Rail End Welding Reaches High Peak on Chesapeake & Ohio. *Railway Engineering & Maintenance*, Vol. 30, June 1934, pages 318-323. Fully describes practice of building-up battered rail ends by the oxy-acetylene process. Heat treating of rail ends on both built-up and new rails is receiving increased attention. WH (7b)

Repairing Cast Manganese Crossings by Welding. F. E. Harrison. *Railway Engineer*, Vol. 55, May 1934, pages 164-165. 77 worn Mn intersections at Newcastle carrying a heavy traffic have been restored by welding. The economy of the project is reflected in the fact that £85 represented in 1924 the average price of each of the cast Mn intersections, while approximately £7 represents the cost of the reconditioning by welding. WH (7b)

Torch Fed with Electrically Heated Gases (Chalumeau à réchauffage électrique des gaz). A. A. Guntz. *Bulletins de la société chimique de France*, Vol. 5, Jan. 1934, pages 259-262. Electric heating coils are incorporated in a torch thus permitting it to run on oxygen or preheated combustion air. The electric energy is utilized completely and a temperature rise of the flame of at least 150°C. is claimed. EF (7b)

Bronze Surfacing in Power Plant Maintenance. T. W. Greene. *Power*, Vol. 78, Aug. 1934, pages 448-450. Examples of the use of bronze surfacing applied to worn parts with special welding rod using the oxy-acetylene blowpipe are given. The welding rod consists of an α-β brass base possessing high tensile strength and ductility. Distributed uniformly through this matrix is a △ constituent formed by the simultaneous presence of certain amounts of Fe and Sn, consisting of innumerable small particles considerably harder than the surrounding metal that act as bearing points to support the load. Presence of small quantities of Mn and Si practically eliminates oxidation and gas inclusion during welding. The mechanics for the application of a good surface are described. AHE (7b)

High Speed Welding with Large Electrodes. F. Giolitti. *Metal Progress*, Vol. 26, Sept. 1934, pages 39-40. Improvements in welding effected by use of large electrodes, 1/4″ to 3/16″ are leading to scrapping of much equipment in Italy. WLC (7b)

Welded versus Cast Jigs. L. E. Fuller. *American Machinist*, Vol. 78, Aug. 29, 1934, pages 610-611. Some examples show superiority of welded jigs over cast jigs regarding cost of manufacture and reproduction. Ha (7b)

The First Welded Arch Bridge (Die erste vollständig geschweisste Bogenbrücke). Fr. Faltus. *Die Elektroschweissung*, Vol. 5, July 1934, pages 134-135. Description of the construction of the bridge of which all parts were welded. GN (7b)

Electric Spot-Welding Machine (Elektrische Warzenschweissmaschine). W. Fahrenbach. *Zeitschrift Verein deutscher Ingenieure*, Vol. 78, July 14, 1934, page 859. Multiple welding by machines is often difficult in that the current passing through the different spots to be welded is not the same in all if the spots are connected in parallel. To obviate this drawback small dents (warts) are at first pressed into the material which give a contact for the current which very quickly heats up to welding temperature; then the pieces are pressed together under high pressure, about 1000 kg. Up to 10 spots can be welded simultaneously, no marks show the place of the warts. A machine especially developed for this purpose of 100 KVA capacity is described. Ha (7b)

Machine Characteristics for Steady Welding. F. Creedy, R. Kogge & A. O. Danello. *Electrical Engineering*, Vol. 53, Sept. 1934, pages 1268-1272. The characteristic a welding generator should have for steady welding was studied with oscillograms and the conclusion derived that steady conditions take place either with no short-circuits in case of a long arc or with regularly periodic short-circuits in the case of a short arc. Coated rods give a much more copious deposit, most likely due to their fluxing action and reduction of oxide layer on the surface of the molten drop; the coating serves also as a heat insulation and so leads to more rapid melting. Oscillograms show welded processes under different circuit conditions. Ha (7b)

Applying Welding to the Construction and Repair of a Wide Variety of Plant Equipment. R. J. Collins. *Welding Engineer*, Vol. 19, Sept. 1934, pages 42-44. Typical applications are illustrated. Ha (7b)

Flame Cutting of Steel for Welded Joints. E. J. CLARKE. *Transactions Institution of Engineers and Shipbuilders in Scotland,* Vol. 77, 1934, pages 13-53. Includes discussion. Experiments are described which show that the oxide coating produced by flame cutting has no deleterious effects whatever on the mechanical properties of joints prepared by this process in mild steel bars or Lloyd's structural steel. It is concluded that the opposition to the use of flame cutting in ship construction is unjustified. The relative advantages of acetylene and coal gas for cutting are summarized in an appendix. JCC (7b)

Electric Arc Welding in Ship Construction. J. L. ADAM. *Transactions Institution of Engineers and Shipbuilders in Scotland,* Vol. 76, 1933, pages 390-486. A comprehensive review of modern welding practice in ship construction, followed by a very full discussion. The necessity for strictly systematizing welding procedure for every class of weld, checking operating conditions regularly, and having adequate inspection, is emphasized. An all-welded ship should be built from preconstructed sections which should be as large as can be handled. Detailed descriptions, illustrated with sketches, are given of the welding of a large variety of structural details. In ordinary ship construction, greater use might be made of welding in such work as bilge construction. Details of the construction of an experimental full sized section of a welded bilge suitable for a 350 ft. steamer are given in an appendix. JCC (7b)

Welding Bronze Rollers to Cast Brass Heads. W. J. CHAFFEE. *Welding Engineer,* Vol. 19, Aug. 1934, page 19. Describes repairs for leakage in hollow rolls of paper-making machinery. Ha (7b)

Welded Rectangular Tanks. G. CALDER. *The Welder,* Vol. 6, June 1934, page 219. Details of design and construction of an underground oil tank 8 x 9 ft. are described. Ha (7b)

Welding and Cutting for Maintenance in the Electric Light and Power Industry. D. D. DETROW. *Welding Engineer,* Vol. 19, Aug. 1934, pages 17-18. Examples are given to show that by using welding and cutting as a repair process the "out-of service time" of equipment can be materially reduced. Ha (7b)

Review of the Technical Literature on Fusion Welding (Revue de la Presse de la Soudure Autogène). J. BRILLIÉ. *Bulletin de la Société des Ingénieurs Soudeurs,* Vol. 5, May-July 1934, pages 1332-1350. Subjects reviewed by the author are divided under the following headings. (1) Use of welding in overhead steel construction. (2) Application of welding in machine manufacture. (3) Use of welding in boiler making. (4) Application of welding in naval engineering. Review is based upon the world literature since last October. FR (7b)

Recently Welded Highway Bridges in Germany. OTTO BONDY. *Welder,* Vol. 6, June 1934, pages 196-199. A few examples of all-welded bridges with spans up to 660 ft. are described with details of construction and erection. Ha (7b)

Electric Arc Welding for Reconditioning of Tramway Rail Systems (Die elektrische Lichtbogenschweissung bei der Überholung von Strassenbahn-Gleisanlagen). H. BAUER. *Verkehrstechnik,* Vol. 51, Aug. 5, 1934, pages 415-416. Building-up of joints of tramway rails is cheaper with arc welding than with the thermite process. Mn steel is employed as filling material. In general, too high current intensities are utilized resulting in hard deposits which do not possess an austenitic structure. For a welding rod of 5 mm. diam. 120-130 amps. at 22-24 volts (arc) are urged. Detailed instructions on carrying out the welding of rails in new layouts are furnished. The use of an adequate welding transformer is stressed. WH (7b)

Electric Fusion Welding and Gas Fusion Welding (Elektroschmelzschweissung und Gasschmelzschweissung). P. BARDTKE. *Autogene Metallbearbeitung,* Vol. 27, June 15, 1934, pages 193-195. Development, special advantages and fields of application of electric arc welding and oxy-acetylene welding are discussed and compared. The introduction of the covered electrode rendered the previously more or less brittle weld of coarse grain structure applicable for structures which are under high dynamic stress, i.e. alternating, fatigue and impact stresses. Recent investigations have shown that much higher peaks of stress occur in electric welding in the seam itself while in gas welding the highest stresses are in the material next to the seam. The choice between the 2 methods will often be determined by local conditions; electric welding requires a greater skill, so that in cases where welding has to be done by personnel which has other duties, fitters, etc., gas welding is preferred. Ha (7b)

Repair and Reinforcement of Bridges by Electric Welding (La Réparation et le Renforcement des Ponts par Soudure à l'Arc). *La Soudure Autogène,* Vol 26, Aug. 1934, page 11. Typical example illustrated. FR (7b)

Researches in Welding (Travaux et Recherches en Soudure). *La Soudure Autogène,* Vol. 26, Aug. 1934, page 15. Short account on works in progress at the "Office Central de l'Acétylène" and dealing with: (1) Metal spraying with oxy-acetylene sprayer. (2) Use of fusion welding in aircraft engineering. (3) Added metal for bronze welding. FR (7b)

Light Weight Design with Shot-Welded Stainless Steel-II. *Product Engineering,* Vol. 5, Aug. 1934, pages 293-295. Further data and formulae are given for typical structural members of welded structures and examples are described. Ha (7b)

Some Results on the Latest Investigation in the Fields of Welding (Eeinige resultaten der laatste onderzoekningen op laschgebied). *Polytechnisch Weekblad,* Vol. 29, Feb. 22, 1934, pages 126-127. Pertains to a discussion on statements of Schmidt and Schmuckler. (See *Metals & Alloys,* Vol. 5, June 1934, page MA 267 R-5). WH (7b)

Modern Sheet Metal Welding. *Oxy-Acetylene Tips,* Vol. 13, July 1934, pages 149-153. Methods of successful and economic application of welding to sheet metal work and organization of the shop are discussed in detail. Preparation of work, proper tools and standardization are among the important factors besides inspection and tests. Ha (7b)

Multi-Flame Lindewelding. *Oxy-Acetylene Tips,* Vol. 13, Aug. 1934, pages 173-178. This process uses backhand technique, a special flame adjustment and a special welding rod producing welds of high strength at great speed. Preparation of work, procedure at welding and examples are described. Surface oxide is avoided by the reducing action of C absorbed by the surface of the base metal from the excess acetylene flame. The blowpipe has 2 flames and attached to it an automatic gravity feed rod holder. Ha (7b)

Well Casings for Permanence. *Oxy-Acetylene Tips,* Vol. 13, Aug. 1934, pages 179-181. Well casing of 1100 ft. length of 12 in. diam. pipe was welded together; procedure is described in full. Ha (7b)

Welding in the Foundry. *Oxy-Acetylene Tips,* Vol. 13, Sept. 1934, pages 203-205. Remodeling, repairing, and other ways of using welding to advantage in a foundry are described and illustrated. Ha (7b)

Metallurgical Cutting. *Oxy-Acetylene Tips,* Vol. 13, Sept. 1934, pages 197-202. A detailed description of methods of flame-cutting of various steels. Ha (7b)

Welded Spherical Manifolds. W. E. ARCHER. *Welding Engineer,* Vol. 19, Aug. 1934, page 26. Describes welding procedure of a sphere of 14 ft. in diam., 22 ft. length with outlet, of 1¼ in. thick plates. Ha (7b)

All-Welded Steel Frame Building for Leland Stanford University. W. E. ARCHER. *Welding Engineer,* Vol. 19, Sept. 1934, pages 26-27. Details of construction and arc-welding procedure are described. Ha (7b)

Some Notes on the Selection and Use of Welding Plant. *Gas Engineer,* Vol. 59, June 1934, pages 292-293. States that a flux-coated electrode requires less experience of the welder, protects against atmospheric gases, keeps the arc burning at a substantially lower amperage and enables the heat to be localized. A stable arc at the correct amperage is very essential to obtain the best results. Practical instructions on manipulating the electrode are furnished and 9 illustrations show some joints and the layout of welding bays. WH (7b)

The Effect of Heat Treatment of Welds. *Engineer,* Vol. 155, May 19, 1933, page 510. See "A Preliminary Research into the Effect of Heat Treatment on Welds," *Metals & Alloys,* Vol. 5, July 1934, page MA 336. LFM (7b)

Specifications for Welded Steel Structures, 1934 (D I N 400) (Vorschriften für geschweisste Stahlhochbauten, 1934 (D I N 4100). *Die Elektroschweissung,* Vol. 5, Aug. 1934, pages 146-151. Paper considers the German specifications on welding of superstructures under the following headings: (1) general, (2) materials, (3) welding methods, (4) calculation of weld seams, (5) admissible loading of weld seams, (6) testing of welders performing (a) flank seams, (b) butt seams, (7) constructional design, (8) performance of welding work, (9) supervision of welding work and inspection. GN (7b)

Testing Methods and Specifications in Welding (Prüfverfahren und Vorschriften). *Die Elektroschweissung,* Vol. 5, Aug. 1934, pages 158-159. Review of recent foreign publications on these subjects with special reference to the British Standard specification for metal arc welding as applied to Steel Structures. 11 references. GN (7b)

Electric Welding in Conveying Industry (Elektrische Schweissung in der Fördertechnik). *Elektrizitätswirtschaft,* Vol. 33, June 15, 1934, pages 226-227. The economy of electric welding utilized in transportation problems is demonstrated by 2 characteristic examples (1) welding of crane rails onto the double I beam and (2) assembling of a grab. In the latter case, for instance, 7% of the total dead weight could be saved due to the adoption of welding. In spite of the weight reduction a stronger and more rigid grab was secured. WH (7b)

Electrically Welded Poles Made of Discarded Rails (Elektrisch geschweisste Tragmasten aus alten Eisenbahnschienen). *Elektrizitätswirtschaft,* Vol. 33, June 30, 1934, pages 254-255. The unique utilization of electric welding is discussed at length, the underlying calculations of the welded masts composed of old rails are presented, and the structural details shown. WH (7b)

Building-up of Tools by Welding (Werkzeugreparatur durch Schweissen). *Elektrizitätswirtschaft,* Vol. 33, June 15, 1934, page 226. Drills, milling tools, molds are shown to be successfully reconditioned by the Arcatom welding process. WH (7b)

English Rules for Welded Structures (Die englischen Vorschriften für geschweisste Stahlbauten). *Autogene Metallbearbeitung,* Vol. 27, July 1, 1934, pages 220-222. The British Standard Specifications for Metal Arc Welding as applied to steel structures which have been proposed to the London County Council, are discussed and compared with the German standard. Ha (7b)

Thermal State During Fusion Welding (Etude Experimentale de l'Etat Thermique Pendant la Soudure Autogene). A. PORTEVIN & D. SEFERIAN. *Comptes Rendus,* Vol. 199, July 2, 1934, pages 34-36; *La Technique Moderne,* Vol. 26, Sept. 1934, page 604 (abstract). Effect of heat conductivity, specific heat, and heat of fusion on metals and alloys during fusion welding studied by determining temperature gradients as revealed by cooling curves from thermocouples placed along weld line of plates, bars and other sections. Shape of piece more important than method of welding. Graphs included show that the thermal state (x, y, z) depends on thermal cycle = Fx, y, z^t. FR+FHC (7b)

Effect of Diameter and Distance Between Bending Rolls on the Results of Bending Tests of Welded Samples (Einfluss von Durchmesser und Abstand der Biegerollen auf die Ergebnisse der Biegeprobe bei geschweissten Proben). K. L. ZEYEN. *Technische Mitteilungen Krupp,* Vol. 2, Mar. 1934, pages 62-63. See *Metals & Alloys,* Vol. 4, Aug. 1933, page MA 250. MG (7b)

Monument Welding (Denkmals Schweissung). VIKTOR WALTER. *Der Autogen Schweisser,* Vol. 7, June 1934, pages 81-83. Deals with the repair of a dynamited monument by means of the oxy-acetylene welding and build-up by welding. Kz (7b)

Foundation for Future Business is Laid upon Welding Work. WM. R. STEVENS. *Domestic Engineering,* Vol. 143, Apr. 1934, pages 36-37. Deals with pipe line welding. Kz (7b)

Build-Up Welding for Repairing of Rail Ends, Frogs and Switches (Auftragsschweissung beim Ausbessern von Schienenenden, Kreuzungen und Weichen). J. STAEBLER. *Autogene Metallbearbeitung,* Vol. 27, June 15, 1934, pages 195-201. American and Polish experiments and experiences are reported with repairing worn-down rail ends on the track by build-up welding. A comparison of costs showed oxy-acetylene welding to be cheaper than electric welding, both from the point of view of first cost for the equipment and for welding cost which amounted to $2.0144 for electric and $0.810 for oxy-acetylene welding per rail end. The same holds true and the same good operating results were obtained by building up worn frogs and switches. The material is put on in small metal drops and hammered when it is still red-hot. Ha (7b)

Small Welding Burner for Sheet Welding and Lead Welding (Klein-Schweissbrenner für Feinblech-und Bleischweissungen). J. STAEBLER. *Autogene Metallbearbeitung,* Vol. 27, May 15, 1934, pages 166-167. Describes small burner for sheets of less than 0.3 mm. and up to 0.5 mm. thickness. Oxygen pressure is 0.3 kg./cm². Acetylene consumption is about 25 l./hr. Ha (7b)

Factors on Which the Hardness of Welds Depends (Faktoren, von denen die Härte von Auftragschweissungen abhängt). K. L. ZEYEN. *Technische Mitteilungen Krupp,* Vol. 2, Mar. 1934, pages 64-67. See *Schmelzschweissung,* Vol. 11, 1932, pages 117-120. Shows that the hardness of welds depends on the loss of alloying elements in the welding wire, therefore on the care exercised in welding, and on the rate of cooling of the weld; this latter depends on the welding process, the thickness of the welded parts, and the number of passes. MG (7b)

Longitudinally Welded Shipping Tanks (Längsnaht-geschweisste Versandbehälter). K. RUPPIN. *Zeitschrift Verein deutscher Ingenieure,* Vol. 78, Sept. 22, 1934, page 1123. Tanks used for shipping liquids have withstood rough operating conditions particularly well if they were welded with longitudinal seams only except the 2 round seams for the bottoms. Preparation of sheets and welding is more economical both for automatic and manual welding processes. Tanks of 9 m. length and 2.6 m. diam. have been built in this manner and operated satisfactorily on railroads. Ha (7b)

Portable Welding Unit Developed for Quick, Efficient Pipe Line Repair. L. G. E. Bignell. *Oil & Gas Journal,* Vol. 33, June 7, 1934, pages 14, 42. Description of portable welding unit mounted on a truck developed by the Welders Supply Co., Tulsa, Okla. VVK (7b)

Shrinking Stresses in Fusion Welded Parts (Schrumpfspannungen in autogen geschweissten Teilen). G. Bierett & G. Gruening. *Autogene Metallbearbeitung,* Vol. 27, Aug. 15, 1934, pages 259-266. The question of stresses in welds caused by shrinking is discussed under consideration of both cases, i.e. free welding, where transverse shrinking is not impeded, and welding, where the parts are rigidly clamped and can not freely follow the strains set up in welding. The comprehensive tests which are described in detail and illustrated in tables and diagrams, show that the amount of heat applied during welding is no sure measure for shrinking stresses; in certain cases, conditions with large heat supply were more favorable than with less supply of heat. It is, however, advisable to limit the heat supply with regard to stresses in such cases in which welding must be done with the parts held in place. In other cases, besides the economical advantage, it may be advisable to limit the heat supply in order to avoid warping. Annealing of the seams is recommended to equalize the stresses. The welding process will always be accompanied by high internal stresses; the original state of internal stress is, however, relieved by additional stresses set up under operating conditions so that the strength of a material is not seriously influenced by internal stresses. Ha (7b)

Present State of Built-up Welding (Über den gegenwärtigen Stand der Auftragschweissung). W. Berndt. *Die Metallbörse,* Vol. 24, July 21, 1934, pages 921-923; July 28, 1934, pages 953-954. Reviews specifications of German State Railroad and new German Welding Standards DIN 1913. Experimental data secured in extensive welding tests are reported showing interrelation between Brinell hardness, welding rod analysis, thickness of welded sheets, current intensities, acetylene, oxygen excess, neutral torch, and C in deposited metal. The experimental results are presented in 5 tables which collect the mean values gained on 6 individual tests. Depending on the regulation of the torch and current intensity respectively, the Brinell hardness in the weld varied between respectively 119-370 Brinell and 161-415 Brinell with respect to the same filler rod. With plain C rods, the hardness of the weld decreased with rising sheet thicknesses for gas welding but increased on welding electrically. The effects on the hardness of superimposing several beads has been studied and is interpreted from metallurgical standpoints. The hardness increased if the successive deposits were allowed to cool down to room temperature first. Cr and W somewhat checked the drawbacks of plain C filler rods. The increase of C in the weld due to excess of acetylene in the torch was found to be considerable. Arc welding with uncoated electrodes yielded higher hardness values than gas welding. EF (7b)

Utilization of Various Welding Methods for Repair Jobs in Power Plants (Anwendung verschiedener Schweissverfahren in Kraftwerken). W. Ellrich. *Elektrizitätswirtschaft,* Vol. 33, June 30, 1934, pages 234-241. Reports on extensive welding tests with different kinds of electrodes (analyses not given) on the German market. The experimental results gained on 16 electrodes are presented in a table which lists coating (in weight % of electrode), welding speed, losses due to spitting and scorification, steel losses, bending angle, bending load. Cold bending tests with samples joined with bare electrodes showed inferior physicals and failed at bending angles of 25-45° as compared with 118° for coated electrodes. Practical experiences and welding results in the largest German power plant are discussed and shown in 16 typical illustrations. Cold welding (Cu, Monel metal, V2A, and other special electrodes) was very rarely a success with cast Fe. Heating of the work to red heat is strongly recommended and the deposition of cast Fe electrically or by fusion is urged. Welding of thin sheets below 3 mm. proved to involve great difficulties unless electric resistance welding is employed. A table states whether and what type of welding can be applied to the various kinds of repair jobs. According to the author, the most valuable electrode is rendered useless in the hands of an unskillful welder. Data on electric cutting jobs are also presented. The cost ratio for a C and 2 special electrodes was 1:9:22. WH (7b)

Strain Measurements in Welded Circular Seams (Spannungsmessungen an geschweissten Rundnähten). Ebel & Reinhard. *Autogene Metallbearbeitung,* Vol. 27, Oct. 1, 1934, pages 305-310. The stress distribution around a circular seam of 700 mm. diam. was measured with a Siebel instrument; the accuracy was ±2 kg./mm.^{2} It is not advantageous to stress-relieve a circular seam by a step-by-step method as eventually an increase in the stresses can occur. This can have a particularly harmful effect in containers with internal pressure, as the latter superposes itself on the welding stress. Annealing of the second belt of the boiler plates with a ring burner has been found effective, the residual stresses after such treatment are so small that practically freedom from stress existed. Ha (7b)

Mechanical Properties of Spot Welds (Propriétés méchaniques des Soudures par Points). Dussourd. *Usine,* Vol. 43, Oct. 11, 1934, page 37. Present methods of spot welding of steel sheets of 5 and 2.5 mm. are discussed. Stress relieving is important as it improves the mechanical properties, especially after natural cooling. Ha (7b)

The Development of Welding as Applied to Boiler Drums and Steam Receivers. C. H. Davy. *Proceedings Institution of Welding Engineers,* Vol. 7, Nov. 1933-Mar. 1934, pages 55-103. Includes discussion. See *Metals & Alloys,* Vol. 5, Sept. 1934, page MA 447. (7b)

New-type Installation Equipment Built of Arc-welded Aluminium. A. F. Davis. *Metallurgia,* Vol. 10, Aug. 1934, page 111. Describes still made by welding Al. JLG (7b)

Arc-Welding Cuts Maintenance Costs in Rock-Products Plant. A. F. Davis. *Welding Engineer,* Vol. 19, Oct. 1934, pages 20-21. Maintenance and repair work of machinery for rock handling is described. Ha (7b)

Good Welding Essentials. A. L. Cummings. *Inspection,* Vol. 5, Apr. 1934, pages 15-24. Paper read before the North-East Coast Branch of the Institution of Engineering Inspection. The essentials of a good welded joint are correct design, quality of electrode, suitable plant, correct amperage and voltage for the various sizes of electrodes and work, correct assembling and tacking together, method of welding to counteract contraction and distortion, proper penetration, homogeneity of weld metal which must be free from porosity and slag inclusions. Dealing with the detection of defects the author points out that welds may be confidently examined by eye, if there is a thorough knowledge of elementary essentials. Features which a good weld should have are discussed and various points which indicate the use of too high or too low currents are explained. Kz (7b)

Arc-Welded Machine Parts of Huge Proportions. D. B. Charters. *American Machinist,* Vol. 78, Nov. 7, 1934, pages 768-769. Parts of a 750,000 lb. press of arc-welded construction are described. Ha (7b)

Welded Construction of a Water Turbine (Schweissgerechte Konstruktion einer Wasserturbine). *Zeitschrift für Lichtbogenschweissung,* Vol. 11, Aug. 1934, pages 1106-1109. In the turbine described, installed at a Finnish power plant, the guide wheels and side walls were made of welded plates. To avoid deformations and subsequent looseness, the welds were made in thin layers and subsequently hammered. GN (7b)

Welded Motorship (Geschweisstes Motorschiff). *Zeitschrift für Lichtbogenschweissung,* Vol. 11, Aug. 1934, pages 1104-1105. Brief description of construction and welding of a Swiss motorship. GN (7b)

Composed Welded Beams (Über zusammengesetzte geschweisste Träger). *Zeitschrift für Lichtbogenschweissung,* Vol. 11, Aug. 1934, pages 1097-1101. In first applying welded beams their arrangement was similar to the riveted beam. This method, however, offered neither economic nor technical advantages. Gradually new types of welded beam constructions were developed of which the most important types are considered. The best type of composed welded beam is that made of a web plate and 2 wide flat irons as flanges joined by 4 weld seams. It offers the following advantages: (1) Simplicity of construction since all types of plates and flats can be used to build the desired beam. (2) Special types of beams can easily be made. (3) Joining of 2 beams making an angle of 90° is facilitated. This type of beam can also be utilized when U shapes must be used simultaneously. Welding costs of the various types of beams considered are finally dealt with. Also welding work required is cheapest for beam made of plates and flats. GN (7b)

Fusion Welding in Aircraft Construction (La Soudure Autogène dans les Constructions Aéronautiques). A. Boutté. *Revue de la Soudure Autogène,* Vol. 26, June 1934, pages 10-16. Lecture before the *French Welder's Society.* It is first pointed out that the designer must know welding technique because unsuitable design can cause (1) Difficulty of operation for the welder. (2) Undue stresses in welded joints. An accurate study of the design is necessary because general strength of finished airplane is not greater than that of the weakest joint. In calculation of resistance it is necessary to take account of the weakening effect of heating in metal surrounding the weld. Details of special tube joints are given dealing particularly with kind of stresses involved in each particular case. A section is devoted to welding technique, heat treatment and repair work. Some examples of construction are illustrated. It is concluded that welding is of much interest in aircraft construction owing to speed of operation and low cost of the process. FR (7b)

Causes of Non-Weldability of Nickel (Causes d'Insoudabilité du Nickel). A. Boutté. *La Soudure Autogène,* Vol. 26, Aug. 1934, pages 6-7. Paper read at the International Acetylene and Fusion Welding Congress in Rome. FR (7b)

All-Welded Railway Station Roof Structures. Otto Bondy. *Railway Engineer,* Vol. 55, Aug. 1934, pages 250-254. The present position of all-welded railway station roof construction is summarized with special reference to modern German practice. Detailed structural features can be taken from 14 illustrations which mainly refer to accomplishments during the last 3 years. WH (7b)

Welding in the Construction of Passenger Coaches. Otto Bondy. *Railway Engineer,* Vol. 55, Apr. 1934, pages 120-123. Discusses the great reductions in the weight of rolling stock which have been achieved in Germany by welding. Data and details on welded design are presented. Testing, stress allowances and German welding rules are dealt with. Bondy states that the principle of self-supporting frame construction has been extensively applied in express coaches of the Deutsche Reichsbahn and the weight of cross stays have been greatly reduced by welding. Tubular members have proved very successful in the frames and bogies of tramcars. As the ideal section to resist buckling, tubes appear to have a great future in the construction of railway vehicles by welding. WH (7b)

Welding Rod Coatings. L. B. Bliss. *Foote-Prints,* Vol. 7, June 1934, pages 12-25. Abstract in *Steel,* Vol. 94, June 18, 1934, page 40. General discussion of materials used for coatings, their physical effects upon the finished rod, and remedies for some of the difficulties experienced in the application of the coating. Gas is generally attributed to C_2H_2 formed by reaction of H_2O with carbides in ferro-alloy. Many of the difficulties due to gas have been overcome by use of a ferro-Mn processed in such a way that the troublesome carbides are rendered inert. Tests indicated that 9 times as much gas is evolved from standard ferro-Mn as is evolved from the treated product when the test is carried out at 30° C. for 3 days. Arc may be stabilized by adding Ti to coating composition. In Al welding, alkali halides have been found to be the best fluxes. Includes a selected list of recent American and European patents on welding rods, coatings, and fluxes. MS (7b)

Judging Welding Electrodes (Beitrag zur Beurteilung von Schweisselektroden). Karl Meller. *Die Elektroschweissung,* Vol. 5, Apr. 1934, pages 61-66, May 1934, pages 91-95; June 1934, pages 106-114; Discussion; July 1934, pages 136-138. Both bare and coated electrodes were investigated. All samples were welded with an automatic welding machine to attain rather uniform welding conditions. As work piece normal commercial St 37 steel plates 10 mm. thick were used. In these tests were measured: melted weight of electrode, weight of deposited welding material, amperage, voltage, energy consumption and welding time. The principal results are: (1) Within a certain current range, generally applied in welding, the weight of electrode melted increases rectilinear with the amperage, therefore, to decrease the welding time and subsequently the welding costs it would be advisable to apply high amperage. However, experiments show that the amperage cannot be increased beyond a certain limit. (2) The weight of electrode melted is practically independent of the arc voltage. The metal losses increase with increasing arc voltage. (3) With increasing amperage the burnt-in area and the transition zone in the material become larger. (4) No definite relations could be established between energy consumption and welding costs, however, the energy consumption increases are about proportional to the voltage. The effect of amperage on welding wages and electrode costs was studied in detail, extensive considerations on the economy of various electrode types in relation to the factors studied are finally outlined, resulting in the statement that welding with coated electrodes is much more expensive than with non-coated ones. Proposals are made to make application of coated electrode more economic. GN (7b)

Welding's Challenge to Steel. Everett Chapman. *Preprint American Iron & Steel Institute,* May 1934, 5 pages; *Blast Furnace & Steel Plant,* Vol. 22, June 1934, pages 333-334; *Steel,* Vol. 94, May 28, 1934, pages 34-36; *Iron Age,* Vol. 133, May 24, 1934, pages 21-22; May 31, 1934, pages 31-32. In advancing the interests of welded steel construction, the author records two impressions; first, the woeful lack of knowledge of steel on the part of the average user, and second, his tremendous curiosity concerning the nature of steel. The answer is that the steel industry should talk about something besides price. Modern weld metal possesses physical properties superior to ordinary material of similar composition which the author believes is due to its cleanliness. VVK + MS + VSP (7b)

Gas Cutting of Very Thick Steel Parts (L'Oxy-Coupage des Pièces d'Acier de Forte Epaisseur). Marc Rivière. *Bulletin de la Société des Ingénieurs Soudeurs,* Vol. 5, May-July 1934, pages 1357-1372. Lecture before the *French Welders' Society.* Gives rules which must be followed for cutting steel of a thickness greater than 300 mm. (1) Preliminary operations are first described. (2) Conditions of cutting operation are discussed and can be summarized as follows: Power of flame must be proportional to thickness to be cut. Length of flame must be at least equal to the thickness of metal. When an oxide crust is present on the steel, power of flame must be increased accordingly. An excess of C_2H_2 is advocated. A slight preheating (200°-300° C.) is favorable. Pressure and supply of cutting 0 must be in accordance with large thickness to be cut. Hand cutting cannot give good results, a mechanical handling of the torch which is necessarily heavy must be used. Automatic displacement of the torch allows an accurate control of the cutting speed. The most delicate point in the operation is the starting up of the cutting. Local preheating must be sufficient, the torch must be near enough to the metal at the beginning and somewhat removed later, displacement of the torch must be slow at the beginning. Part to be cut must be placed so that the 0 jet is tangential to the metal. Before the end of the cut, speed must be reduced (those speed rules are not necessarily followed when the steel part has a round section). FR (7b)

Electrically Welded Bucket Chains of Steel Pipe (Elektrisch geschweisste Elmerleitern aus Stahlrohr für Bagger). F. Riedig. *Die Elektroschweissung,* Vol. 5, Sept. 1934, page 178. Description of construction and welding of such bucket chains. Saving in weight amounts to about 35-40% as compared with riveted construction of same size. Welding does not impair rigidity and strength of construction. GN (7b)

The Status of Welding in Marine Construction. Paul Orr. *Welding Engineer,* Vol. 19, Oct. 1934, pages 22-23. Welding procedures to meet the rigid requirements on board ship are discussed and examples of welded parts and equipment described. Ha (7b)

Electrical Resistance of Iron Deposited by the Arc Welding Process. Minoru Okada. *Journal Institute of Electrical Engineers of Japan,* Vol. 53, Feb. 1934, pages 85-88, in Japanese; Abstract Section, page 11. In English. The electric resistivity of low C steels (0.01-0.18% C) deposited by arc welding was measured. Electric resistivity, porosity, micro-structure and chemical composition of the Fe deposited vary considerably according to the different kind of welding rod employed. Although molten Fe absorbs gases, mainly N_2 and O_2, during the welding process, their effect upon electric resistivity and porosity is comparatively small, but the effect of the chemical composition of the deposited Fe on the resistivity is notable. Experiments with molten Fe deposited from electrolytic Fe rods of extreme purity showed the minimum resistivity but the maximum H_2 content. Concludes that the rod having as little impurities as possible is preferable for welding of third rails and of other low C steel conductors if the welded joint does not require the higher physical strength. WH (7b)

Welded Steel Structures. H. C. Hans Schmuckler. *Iron & Steel Industry,* Vol. 7, Apr. 1934, pages 235-236. The main advantage of welded construction is a saving of weight as compared with riveted or casting work. Engineers trained in welding technique and general steel construction are necessary for the proper understanding of specifications of almost every country. Arc welding has preference over gas welding on economic grounds. Tubular construction can be used where reduction in dead weight is important. Costs of welds vary directly with their length but as the square of their depth. X-weld is the most economical where it is possible to turn the work. Reliable worker can be trained in welding school or in welding plant. Each welder is usually tested at work. X-ray testing, electromagnetic devices and electro-acoustic methods are used in testing of welds. CEJ (7b)

Research on Welded Joints (Untersuchungen an Schweissverbindungen). W. Schick. *Technische Mitteilungen Krupp,* Vol. 2, Mar. 1934, pages 43-62. A long paper on the strength of various kinds of arc welds, particularly fatigue strength, describing an alternating tension and compression testing machine and giving detailed results of tests on 27 different types of joints made with the same welding technique on the same steel. Discusses the stress distribution in these types. Obtained higher fatigue strength on diagonal-seam lap welds. MG (7b)

Energy Transformation in the Welding Arc (Der Energieumsatz im Schweisslichtbogen). Sandelowsky. *Die Elektroscheissung,* Vol. 5, Sept. 1934, pages 178-179. Briefly summarizes results of experiments on energy consumption in arc welding. Of total heat produced were consumed: melting of electrode, 17%; melting of seam edges, 9%; radiation of arc, 15%; heating of plates, 29%, convection and radiation of plates, 30%. Results show that heat consumption for melting electrode in relation to total heat consumption is very small though the other losses essentially depend on size of work piece welded. GN (7b)

Metallographic and Mechanical Characteristics of arc welded seams (Caratteristiche metallografiche e meccaniche di saldature elettriche ad arco). I. Musatti & A. Reggiori. *La Metallurgia Italiana,* Vol. 26, May 1934, pages 303-321. Welding tests are made on a steel containing about 0.2% C. Photomicrographs of the seams indicate that there is a zone of greater hardness and having a coarse crystal structure adjacent to the welded seam. The added metal, whose composition is similar to that of the base metal, shows a finer structure, because of the successive reheatings. Subsequent heat treatment can be made to eliminate the super-heated zone, as well as the zone of excessive hardness. Covered electrodes are used to prevent excessive adsorption of O_2 and N_2 by the metal during welding. The use of covered electrodes makes it possible to produce seams having tensile strengths almost equal to that of the base metal itself. AWC (7b)

Stainless Steels and Their Treatment. F. Leverick. *Proceedings Institution of Welding Engineers,* Vol. 7, Nov. 1933-Mar. 1934, pages 19-38. Includes discussion. See *Metals & Alloys,* Vol. 4, Nov. 1933, page MA 354. (7b)

Additional Materials for Automatic Welding (Zusatzwerkstoffe für die automatische Lichtbogenschweissung). Franz Leitner. *Die Elektroschweissung,* Vol. 5, July 1934, pages 121-127. Paper discusses requirements that core electrodes for automatic arc welding have to meet; good welding with such electrodes essentially depends on ionization of air path, chemical composition of core material and number of welding drops passing upon weld. In considering the various points author first refers to results of experiments on plate seam welds made with a 5 mm. diameter bare electrode. The welding speed varied from 6-18 m./hr. It results: (1) spray losses, penetration of fused metal in base metal and weight of electrode fused do not fluctuate considerably within above mentioned welding speed, (2) 0 and N contents of the weld increase with increasing welding speed, (3) the tensile strength of the weld increases with the welding speed, (4) the zone of base metal affected is largest with low welding speed and vice versa, the extension of this zone is indirectly proportional to the welding speed, (5) rapid freezing with high welding speed brings about increased porosity of the weld. These results go to show that increased welding speed, while bare electrodes are used, is disadvantageous. Therefore, it is advisable to use special core electrodes and not to increase the welding speed beyond a certain optimum limit. Various types of core materials and their effect on the welding properties of the weld are considered. The effect of the arc length on the properties of the weld are also studied. It is stated that a long arc impairs considerably the quality of the weld. The advantages of welding with core electrodes are pointed out. GN (7b)

FINISHING (8)

H. S. RAWDON, SECTION EDITOR

Applying Finish to Chevrolet Bumpers. J. M. Bonbright. *Machinery,* N. Y., Vol. 41, Nov. 1934, pages 158-160. The pickling, cleaning, plating and buffing operations on bumpers are described in detail. Ha (8)

Pickling (8a)

The Recovery of Phosphoric Acid in the Pickling Process. *Engineering,* Vol. 138, Aug. 31, 1934, page 221. From a paper by J. P. Pheiffer entitled "Pickling Wrought Iron and Steel by Means of Phosphoric Acid" presented at the World Petroleum Congress, London, July, 1933. LFM (8a)

Polishing & Grinding (8c)

Modern Round Grinding (Neuzeitliches Rundschleifen). *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, May 20, 1934, pages 298-299. Abstract of a paper by Kaeser before "Arbeitsgemeinschaft deutscher Betriebsingenieure." See "Round Grinding," *Metals & Alloys,* Vol. 5, Nov. 1934, page MA 526. GN (8c)

More Economy in Handcraft by Power Tools (Mehr Wirtschaftlichkeit im Handwerk durch Kraftwerkzeuge). *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, May 20, 1934, pages 288-291. The paper particularly refers to modern grinding machines numerous types of which are described and shown. GN (8c)

Recent Progress on Grinding of Rolls and Drying Cylinders (Neues über das Schleifen von Kalanderwalzen und Trockenzylindern). Walle. *Wochenblatt für Papierfabrikation,* Vol. 24, June 2, 1934, pages 388-389. The peculiar requirements demanded of rolls employed in paper industry are pointed out and 6 of the more important recent improvements on grinding rolls and cylinder drums of 1250 mm. diam. max. and 10,000 mm. length are discussed. EF (8c)

Electroplating (8d)

Improvement of Die Castings by Electroplating (Galvanische Veredelung von Spritzgusserzeugnissen). *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, July 29, 1934, page 483. Discuss points to be observed in electroplating die castings and outlines modern practice in this field. GN (8d)

Electrolytic Nickel Coatings for Decorative Art (Les revetements électrolytiques de nickel en decoration). Marcel Bally. *Revue du Nickel,* Vol. 5, Jan. 1934, pages 52-64. Nickel can be plated to a thickness of several millimeters (3). Bright nickel usually is brittle and non-adherent. Matte nickel has excellent properties but is more costly because of the extra polishing required. Tests for determining depth, adherence, and porosity of nickel coatings are described. American and French Railways specifications for nickel plating are given. AH (8d)

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Sources of Troubles in Brass Plating and their Correction (Fehlerquellen beim Messingplattieren und ihre Behebung). Robert G. Snelling. *Chemiker-Zeitung,* Vol. 58, Aug. 22, 1934, pages 680-681. A pronounced red color of the deposit is caused by the Cu content being too high. This may result from low current density, low NH_4OH or NH_4Cl concentration, high Cu content of the solution, or high temperature. The best operating temperature is 20°-22° C. A light color is caused by low temperature, high current density, or high Zn, NH_4OH, cyanide or NaOH content of the solution. To lower the Zn content it is best to replace some of the brass anodes by Cu. Cu anodes can be used exclusively and the Zn introduced directly into the solution. A dark color results from a high As content. As is used as a brightener, but the solution should not contain over 30 g. As/l. As can be replaced by phenol. A rough deposit may result from the current density being too high, the solution too concentrated, or too many solid impurities in the solution. In the latter case it should be filtered. A dull deposit may be caused by too high current, too concentrated solution, or a low concentration of free cyanide. Too much cyanide must be avoided. The deposit will be thin if the solution is too cold, the plating time too short, metal concentration of the solution too low, current density too low, cyanide content too high, the concentration of conducting salts in the solution too high, or if the anodes are polarized. If these conditions are very pronounced no deposit will result. A deposit having low corrosion resistance results if the Zn content of the deposit or the concentration of alkali in the solution is too high. Inferior throwing power of the solution results if the concentration of conducting or metallic salts, the current density and/or the temperature are low. CEM (8d)

Protective Value of Ni and Cr Platings (Sul valore protettivo dei rivestimenti galvanici di nichel e di cromo). F. Pietrafesa. *La Metallurgia Italiana,* Vol. 26, May 1934, pages 322-330. The protective action of Ni and Cr plating on metals and alloys, the replacement of Ni plating by Cr plating, and the min. thickness of coating to insure protection have been studied. Fe, Ni, Cu, brass, and alpax (Al-Si alloy) were plated with Ni as well as Cr, the Ni plating being carried out at 25° C., and 1 amp./dm.^{2} while the Cr plating is carried out at 10.5 amps./dm.^{2} for Fe and Ni. and 20 amps./dm.^{2} for the last three. Resistance to corrosion in a spray of 20% NaCl solution was determined with the results: Ni shows electrolytic action (cathodic) on Fe, Cu and brass, hence, there is protective action only when the plating is completely non-porous. On Fe, the Ni film must exceed 0.050 mm. for complete protection, while on Cu and brass, a 0.025 mm. film is satisfactory. Cr is cathodic against Fe, and either anodic or cathodic against the others depending on whether the corrosion conditions are such that the chromium is active or passive. The porosity of the Cr film diminishes with increasing film thickness. Films up to 0.006 mm. have little protective action on Fe, Cu or brass. However, 0.001 mm. is sufficient coating on alpax, providing the material is washed and dried after use. 0.002 mm. is sufficient plating on Ni. For satisfactory Ni plating on Fe and Cr plating on Cu and brass, an undercoat must be used. 15 references. AWC (8d)

Undercoats in Nickel and Chromium-plating (Sugli strat intermedi per la nichelatura e par la cromatura). F. Pietrafesa. *La Metallurgia Italiana,* Vol. 26, July 1934, pages 499-506. In Ni plating Fe, an undercoat of Cu helps, while two undercoats of Ni and Cu followed by Ni are still better. A final layer of 0.5-1.0 microns of Cr on the above, gives still better results. Good results are obtained by plating 0.5-1.0 microns of Ni over iron, while over Cu or brass, a Ni layer of 6-10 microns is sufficient. Increasing the Cr layer to 2 microns decreases the protection because of cracking. Cd cannot be used as undercoat in Ni plating on Fe. The bath for rapid Ni plating shows much promise as a time saver and also because of the firm coating obtained. AWC (8d)

Chromium Plating from Water Solutions of Chromic Acid Containing Hydrofluoric Acid (Über die elektrolytische verchromung aus Flusssäure enthaltende wässrigen Chromsäurelösungen). Erich Mueller & Herbert Drechsel. *Zeitschrift für Elektrochemie,* Oct. 1934, Vol. 40, pages 707-713. Parallel tests of chromium plating solutions with H_2SO_4 and HF made to determine relative throwing power and appearance of plate. Current efficiency is affected by temperature more with H_2SO_4 than HF solutions. at 23°C. HF has better efficiency, at 40°C. H_2SO_4. HF concentration-bright plate range is very wide for HF at 23°C. thus bright plating is possible with cold HF solutions with high current efficiency. Throwing power of HF is greater than H_2SO_4 solution. Addition of KF to a H_2SO_4 solution does not increase the throwing power but only the ability to obtain bright plates from a cold bath. The relatively high resistance of lead anodes used with HF plating bath can be lowered by alloying lead with Sb. WB (8d)

Large-Scale Electro-Plating of Zinc. *Engineering,* Vol. 138, Aug. 24, 1934, pages 190-191. Conditions for overcoming difficulties usually encountered in zinc plating are recommended. Acid must be used in sufficient quantity to prevent production of basic salts but not enough to cause serious loss of current efficiency. The maximum permissible acid concentration is greater, the purer the electrolytes used, and the higher the current density. Metallic impurities which will deposit ahead of the zinc should be absent from the electrolyte. If the pH be low, efficient circulation is necessary to prevent spongy deposits. Raising the current density will also check the deposition of spongy zinc. Arsenic which is generally found in commercial zinc can cause the surface of deposited zinc to be rough. Electroplating has many advantages over the galvanizing process, namely, ease of control of thickness of coating and color of surface, high purity of zinc deposited, more rapid working and more economical results. LFM (8d)

Detection and Removal of Inferior Chromium Platings on Sheets (Zur Bestimmung und Entfernung mangelhafter Verchromungen von Blechen). Werner Fröhlich. *Die Metallbörse,* Vol. 24, Aug. 18, 1934, pages 1049-1050. Method of testing Cr plating depends on the basis metal. Porosity of Cr deposits on steel is detected by dipping into $CuSO_4$ solutions. Red Cu deposits indicate the spots where the Fe sheet was unprotected. Another test utilizes NaCl (10 g./l) and K-ferricyanide (1 g./1). The former attacks the Fe while the latter indicates by a blue color the dissolved Fe. For Cr plated brass and Cu sheets, a solution of 100 cc. conc. $HNO_3 + 2$ g. K ferri- or ferro-cyanide is utilized. Difficulties arise with Cr plated Ni since both are attacked to practically the same extent by most reagents. A solution containing equal parts of conc. HNO_3 and H_2O containing 2 g. dimethylglyoxime is suitable. However, the first pink spots indicating porosity do not appear for 12-24 hours whereas the other mentioned reactions take place in about 30 minutes. An electrolytic test, which requires about 2-3 minutes, is based on certain bath conditions under which Cu can be deposited only on Fe, brass or Cu cathodes but not on Cr: Potential, .02 volts; distance between anode and cathode, 5 cm.; bath, 200 g. $CuSO_4 + 75$ g. H_2SO_4/liter H_2O. This method is the most satisfactory one although it requires a relatively inexpensive electrolytic arrangement. Poor Cr platings can be removed chemically (HCl) and electrolytically. Pickling in HCl is the quickest method but some of the underlying steel goes also into solution. In the case of Cr-plated Ni, less of the basis metal is dissolved. Overpickling often spoils the sheets for further Cr plating. This can be entirely avoided by electrolytic Cr removal: electrolyte; 35-40 g. NaOH/liter H_2O; temperature, 80-95° C.; potential, 6 volts. The sheets, which are used as anodes, must be free from grease, resinous matter, silicates and chlorides. EF (8d)

Cobalt plating (La Cobaltatura). O. Macchia. *Industria Meccanica,* Vol. 16, Sept. 1934, pages 744-745. The technique of Co plating is similar to Ni plating; the 5 common plating solutions of Kalmus, Pfannhauser, and of an unnamed author (*Metal Industry,* London, Vol. 26, 1934, page 530) use cobalt sulphate with or without addition of sodium chloride and boric acid. Exact composition and working procedures are described, current density varies from 1.0 to 17.5 amp./dm^2. 12 references. Ha (8d)

Metallic Coatings other than Electroplating (8e)

Precise Gas Regulation Needed to Metallize Successfully. E. M. Evleth. *Metallizer,* Vol. 2, Aug. 1934, page 8. The importance of gas regulation and means for attaining precision are discussed, a chart is given showing delivery pressure of various types of regulators. Regulators of the two-stage type, a combination of the nozzle and the stem type, are recommended. BWG (8e)

Boyden Explains the Mechanical Features of Metal Spray Equipment. Charles Boyden. *The Metallizer,* Vol. 2, July 1934, pages 10-12. The development, construction and operation of modern metal spraying pistols are described and illustrated. BWG (8e)

Behavior of Sprayed-Metal Coatings Towards Liquid and Gaseous Media (Verhalten gespritzter Metallüberzüge gegen flüssige und gasförmige Stoffe). H. Reininger. *Metallwaren Industrie & Galvano Technik,* Vol. 32, June 1, 1934, pages 235-236. The author holds that liquids and gases become overheated in the minute pores of sprayed metal coatings and thus cause flaking off of the coating. Metal spraying is not suitable for vessels used for boiling liquids. A coat of sprayed Zn protects Fe against rusting since the corrosion products of Zn fill up the cavities and "micropores" of the surface layer. EF (8e)

It Was No Easy Job. William Reid. *Metallizer,* Vol. 2, Aug. 1934, page 2. Difficulties encountered and proper procedure followed in coating large water tanks by spraying with Zn. BWG (8e)

Resurfacing of Corroded and Worn Equipment at Refineries found Practical and Economical. H. R. Leland. *Oil & Gas Journal,* Vol. 32, Apr. 19, 1934 pages 36, 44. See "Application of Aluminum to Reaction Chambers Prevents Metal Loss," *Metals & Alloys,* Vol. 5, July 1934, page MA 341. VVK (8e)

Progress in the Metallizing Process (Metalliseringens framsteg). *Teknisk Tidskrift,* Vol. 64, June 2. 1934, pages 239-240. Describes a modern machine, with spraying capacity of 36 kg. lead, 20 kg. tin, 10 kg. zinc, 3 kg. nickel, 2.5 kg. aluminum, and 2.2 kg. stainless steel per hour. It operates with a mixture of acetylene, oxygen, and compressed air, introduced through three separate lines. Speed of blower 30,000 r.p.m.; speed of metal particles, 200-300 m. sec. BHS (8e)

Suggestions from Switzerland. Hans Eckstein. *Metallizer,* Vol. 2, July 1934, page 1. Unusual applications of metal spraying are described: such as the protection of dynamite by covering with a sprayed metal layer; construction of canteens, detonators of hand grenades and flares, and machine gun cartridges from paper coated with sprayed metal; the use of sprayed gold and silver for decorative and architectural effects; duplication of museum metal relics by metal coating plaster duplicates; metal covering of radio tubes; and even the preservation of eggs and Edam cheeses by metallizing. BWG (8e)

Non-Metallic (8f)

The Anodic Oxidation of Aluminium and Its Alloys for Protection and Decoration. George O. Taylor. *Metallurgia,* Vol. 10, Oct. 1934, pages 173-176. Anodic treatment is carried out in either a H_2SO_4 or a Cr_2O_3 bath. When appearance is important the surface must be polished, sand blasted, or wire brushed before treatment. From 30 to 60 min. are required to obtain the maximum thickness of coating. Coatings can be colored with dyes. JLG (8f)

Friction Losses in Bitumastic Lined Water Pipes. Charles W. Sherman. *Journal American Water Works Association,* Vol. 25, Feb. 1933, pages 244-247. Tests on 2340 ft. of 12 in. pit-cast iron, lined with bitumastic enamel, after 1-1/2 yrs. service gave a range for the Williams-Hazen formula of $C = 124\text{-}203$ with an average of $C = 167$. If the nominal diameter instead of the actual diameter of the pipe is used, $C = 158$. VVK (8f)

The Drying of Finishes on Refrigerator Boxes and Parts. C. F. Mayer. *Industrial Heating,* Nov. 1934, pages 135-137. The treatment of the metal before vitreous enamel is burned on at about 1600° F., and types of furnaces for quantity production are described. Ha (8f)

A Nickel Bath in the Pickle Room? G. W. Hofstetter. *Enamelist,* Vol. 12, Oct. 1934, pages 15-16. Good results have been obtained by using a Ni "flash" on sheet iron prior to enameling; it prevented fish scale, increased adherence and decreased tendency to chip. Uniformity of Ni deposit is essential; a good bath is 4½ oz. double Ni salts and ¼ oz. boric acid in 1 gal. of water. This corresponds to about 3/4 oz. of metallic Ni per gal. with a pH of 5.9. Best methods of application are discussed Ha (8f)

Covering of Wire by Winding and Enameling. Rob. W. Withington. *Wire & Wire Products,* Vol. 9, Sept. 1934, pages 333-335. Machinery, raw materials and processes relating to enameling of wire are discussed. Ha (8f)

Paint Requirements. Harold M. Wick. *Marine Engineering and Shipping Age,* Vol. 39, Aug. 1934, pages 308-309. Discussion of protective and decorative paints for steel as used by shipyards. Kz (8f)

Research on Maritime Growth on Ships (Die Forschungen über den Schiffsbewuchs). Wolfgang Neu. *Forschungen und Fortschritte,* Vol. 10, July 1, 1934, pages 248-249. Addition of poisonous Cu and Hg compounds to the anti-rust coatings on ship hulls did not lead to antifoulings universally applicable. Over 100 different animal and vegetable varieties may occur on such paint coatings. The hope of finding a universal anti-fouling of rust inhibiting nature is not too bright. An entirely new view-point is brought up, i.e. the utilization of corrosion resistant light metal alloy hulls which do not require a paint coating. EF (8f)

The Bonderizing Method (Das Bonderverfahren). Fr. Kolke. *Oberflächentechnik,* Vol. 10, June 6, 1933, pages 127-130. See *Metals & Alloys,* Vol. 5, July 1934, page MA 342. Ha (8f)

Difficulties in Painting of Copper with Oil Paint (Schwierigkeiten beim Anstreichen von Kupfer mit Oelfarben). F. J. Peters. *Korrosion und Metallschutz,* Vol. 10, Apr. 1934, pages 91-93. It has been observed that oil paint on Cu dries very irregularly. Investigation showed in all cases that for a metal containing more than 99% Cu, paint with a linseed base was unsatisfactory. Such a paint should not be used for priming. The greater the alloy content of other metals in a copper alloy the fewer difficulties in drying are experienced. Ha (8f)

TESTING (9)

Inspection & Defects, including X-Ray Inspection (9a)

C. S. BARRETT, SECTION, EDITOR

Use of Photo-Electric Cell for Measurement of Brightness and Color of Metals (La Cellule photo-électrique et son emploi dans la mesure de l'éclat et de la couleur des métaux). René Toussaint. *Revue de l'Aluminium*, No. 61, May 1934, pages 2403-2414. Accurate measurements can be made with the photo-electric cell of rates of corrosion, composition of polychromatic alloys, drawing temperature of steels, etc. Dural H, Almasilium, Duralumin, Studal MM, 99% and 98% Al are studied as to their relative brightness and color. Studal has the minimum brightness and Dural H the maximum. For the 99% Al the brightness is 3% less in the direction perpendicular to the direction of polish than in the parallel direction. Comprehensive data and numerous curves given. AH (9a)

All Tests of Cast Iron on one Specimen (Tous les Essais des Fontes sur une même Éprouvette). P. Nicolau. *Bulletin de l'Association Technique de Fonderie*, Vol. 8, July 1934, pages 296-305. Paper presented at the Nancy Foundry Congress, July 1934. The 5.64 mm. diameter test specimen used by Fremont in his shear test is the one proposed for all physical and mechanical tests. Shear, transverse bending, impact, alternate bending, modulus of elasticity (Rolland), compression, hardness, magnetism, resistivity, thermo-electric, and density measurements and methods for this size of specimen are discussed. Ten references. WHS (9a)

Nature of Flakes. V. D. Neskuchaev. *Domez*, No. 6, 1934, pages 30-37. In Russian. X-ray examination of flakes and the adjoining areas in Cr-Ni steels gave the same values, 2.8673 ± 0.0004. Condensed spark spectroscopic analysis using flake free and flaky electrodes of the same steel showed that either there is no difference in the composition of the flake and the rest of steel or the thickness of it is less than 2 microns. Cathodic spraying did not distinguish flakes from the matrix. On heating in vacuum the color of the steel containing flakes lightened until it was impossible to distinguish the metal from the flakes, particularly in the temperature interval 950°-1100°C. Flakes are formed by volatilization of Fe and Ni in spaces formed either by fractures or by blowholes. On hot working they weld in spots instead of all over, which permits their location. Flakes of a rounded shape originate from the blowholes in the ingots. Those with a more ragged appearance are associated with the hot work of the metal. (9a)

Electronic Inspection. R. D. McDill. *American Machinist*, Vol. 78, Nov. 7, 1934, pages 763-765. Principles and advantages of applications of electronic tubes are briefly explained and illustrated by examples of installations for inspection and gaging. Ha (9a)

X-Ray Investigation of the Effect of Rate of Deformation on the Structure of an Alloy Compressed at Elevated Temperatures. E. F. Bachmeteff. *Transactions Scientific Research Institute of Aircraft Materials*, No. 1, 1933, Leningrad, Moscow, U.S.S.R., pages 5-33. When a cold worked alloy is heated recrystallization occurs; the greater the previous deformation the lower temperature and shorter the time necessary for recrystallization. If the deformation of the metal is carried out at the temperature of recrystallization we may expect either complete recrystallization or no recrystallization, depending upon the rate of deformation. The present investigation was carried out on rolled duralumin (4.5% Cu; 0.5% Mg; 0.5% Mn, balance Al). cylinders of which were compressed at elevated temperatures in an Amsler testing machine. The specimens were held at 500° or 510° C. for 30 min., then lowered to 500°, 450°, 400°, 350° or 300° C. and maintained at constant temperature during the period of compression. At the end of compression the specimen was quickly removed from furnace and quenched in water at room temperature. Using X-ray diffraction the structures of these compressed cylinders were compared with the structures of similar uncompressed cylinders which had passed through the same heat-treating procedure. The rates of compression used were 0.0015 to 1.24 mm. per second. The author concludes that at a given temperature of deformation the alloy may be practically recrystallized or not depending upon the rate of deformation. AIK (9a)

A Contribution to Materials Testing with γ-rays (Ein Beitrag zur Werkstoffprüfung mit γ-Strahlen). F. Stäblein & W. Tofaute. *Technische Mitteilungen Krupp*, Vol. 2, Sept. 1934, pages 101-105. An experimental application of radium preparations to the radiographic examination of fabricated metal objects confirmed the work of others on the capability of the method to detect defects. It was demonstrated that the method is a valuable addition to X-ray testing methods when applied to steel with a wall thickness of from 70 to 250 mm. and in the examination of parts otherwise accessible with difficulty. MG (9a)

Physical & Mechanical Testing (9b)

W. A. TUCKER, SECTION EDITOR

Theoretical and Experimental Investigation on Thin-walled Steel Constructions under Buckling Loads (Teoretiska och experimentella undersökningar över knäckbelastingen vid tunnväggiga stalkonstruktioner). W. Weibull. *Ingeniörs Vetenskaps Akademiens Handlingar*, 1934, No. 128, 26 pages. The greater strength of steel in comparison with duralumin and wood and its greater specific weight make it possible and necessary to work with very small thicknesses when utilizing steel as a structural material for airplane wing struts. This introduces a danger of breaking due to axial pressure loads. Methods of calculating purely axial loads in rectangular tubes and channel profiles and formulae for the elastic stability limit have been worked out. However the actual breaking limit in tests was more than twice the computed stability load. This divergency is interpreted and approximate formulae for calculating the actual breaking limit which is attained when the limit of yield point has been reached at the corners of the struts are derived and verified experimentally. EF (9b)

Hardness Testing by Striking with a Pendulum (Härteprüfung mit dem Pendelfallwerk). R. Walzel. *Stahl und Eisen*, Vol. 54, Sept. 13, 1934, pages 954-957. A 10 or 5 mm. diameter ball was mounted in the striking edge of the pendulum of an impact testing machine, the sample tests being attached to the anvil. The angle of rebound indicates the energy absorbed and hence the hardness. This pendulum hardness was related to Brinell hardness by testing a large number of steels of varying hardness. The ratios between pendulum and Brinell hardness are shown in curves. The method was used for measuring the "hot hardness" of several steels at temperatures up to 900°C. As determined by this dynamic method an increase in hardness corresponding presumably to the increase in strength which ordinarily occurs in the blue heat region at about 300°C., occurred instead at about 500°. SE (9b)

The AMSLER Systems of Measuring the Loads Applied in Metal Testing Machines of Hydraulic Construction

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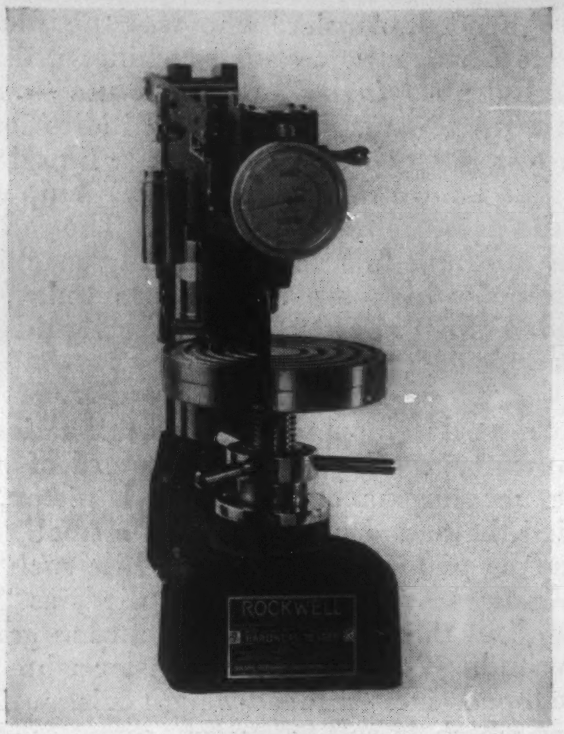

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Welding Stresses. Part I. A New Method of Measuring Welding Stresses and the Effect of Drawing Temperature and Time on the Initial Stresses in Electric Welding. Part II. Residual Stresses in Gas Fusion and Arc Welding. (Beitrag zur Frage der Schweissspannungen. I. Ueber ein neues Verfahren zur Messung von Schweissspannungen und den Einfluss der Anlasstemperatur and dauer auf die Eigenspannungen beim Elektroschweissen. II. Restspannungen bei der Gasschmelz- und der Lichtbogenschweissung). Hans Bühler & Wilhelm Lohmann. *Die Elektroschweissung,* Vol. 5, Aug. 1934, pages 141-145; Sept. 1934, pages 165-170. For determining the plane state of stress near weld seams the drilling method developed by Sachs for cylindrical bodies was changed to make it applicable to thin circular shaped plates. The plates were provided with concentric weld seams and then concentrically drilled step by step, the change of plate diameter was studied progressively. For these changes the course of the tangential and radial stresses can be determined. Also the order of magnitude of the stresses can be determined sufficiently accurately. According to this method the effect of drawing temperature and time on the amount and distribution of welding stresses in St. 37 and St. 52 was investigated. No remarkable stress relief was attained by drawing up to 100°C. Above this temperature the remaining stresses in St. 37 steadily decreased with increasing drawing temperature, so that above 500°C the seams were free of stresses. The course of stress relief is similar in St. 52, though somewhat slower. By drawing to 600° C. the stresses are removed almost completely. By drawing for 2 hrs. at all temperatures investigated the largest possible stress relief corresponding to these temperatures was attained. Therefore, it can be stated that drawing of welded work pieces at 500°-600° C. brings about complete stress relief. Part II To elucidate the question whether the stresses in electrically welded or those in autogenously welded pieces are greater the authors used the method described in Part I of this investigation. Circular plates of St. 34, 20 mm. thick, diameters: 245, 500 and 1000 mm. were provided with concentric grooves (diameter 150 mm.) on both sides and then filled up with welding material. The stresses in the plates thus welded were measured according to the drilling method. In arc welding both covered and bare electrodes were studied. In all cases the largest tension stress was apparent within or near the seam. Results: Plate diameter 245 mm.: In the electrically welded plates the welding stresses showed no considerable difference whether coated or non-coated electrodes had been applied. The residual stresses in electric welds were much higher than in gas fusion welds. Plate diameter 500 mm.: The stresses in both types of welds are about alike. Plate diameter 1000 mm.: Autogenous welds show higher residual stresses than electric welds. In this group of tests arc welds with coated electrodes gave smallest stresses. These tests prove that the residual stresses in gas fusion and electric welds depend upon the size of work piece. The size of residual stresses very much depends upon the cross-sectional ratio between heated area and total area of work piece. GN (9b)

Dependence of the Elongation of Boiler Plate on the Tensile Strength, Specimen Section, and Plate Thickness (Abhängigkeit der Bruchdehnung bei Kesselblechen von der Zugfestigkeit, dem Probenquerschnitt und der Blechdicke). R. Hessler. *Stahl und Eisen,* Vol. 54, Sept. 6, 1934, pages 928-931. After 9700 tensile tests of boiler plate with a tensile strength of 35 to 44 kg./mm.^{2}, the relations between the elongation and the tensile strength, cross-sectional area, and thickness of plate were examined. As was to be expected the elongation increased with area of cross-section of the tensile specimen and decreased with plate thickness. SE (9b)

Measurement of Surface Hardness (Mesure de la Dureté superficielle). G. Lebruly. *Revue de Fonderie Moderne,* Vol. 28, Nov. 10, 1934, pages 311-313. Brief description of methods and apparatus as built by Rockwell and Vickers. Ha (9b)

Evolution of the Impact Testing Method (De ontwikkeling en de tegenwordige stand der kerfslagproof). *Polytechnisch Weekblad,* Vol. 28, Jan. 11, 1934, pages 23-24. An historical review on the evolution of the impact test and the material defects revealed by this testing method. Recent experiments carried out by Stark with the Charpy machine are discussed. Based on a great number of test pieces provided with different kinds of notches, the impact testing machine was found to express the properties of the material under test. The results are affected by chemical composition, degree of rolling, heat treatment and shape of test pieces particularly by the ratio width: height. The impact values were higher with round grooves than in the case of sharp-edged ones. The most favorable ratio of width: height=1:1 has been corroborated. WH (9b)

Cast-on or Cast-off Test Bars for Cast Iron. *Machinery,* London, Vol. 44, June 7, 1934, pages 274-275. The provisions of the British Standards Specifications, concerning tensile and transverse test pieces for gray cast iron, leave the choice of cast-on or cast-off test bars to the makers, stipulating only that the bar metal be cast at the same time and from the same ladle as that for the casting itself. Both as regards tensile and transverse test pieces, whereas formerly in each case a single size test piece served for each and every casting thickness, now there are 3 tensile and 3 transverse test bar sizes, graded to approximate more nearly to actual thickness present in the castings represented. The test bar shall be cast in such a manner that it is as nearly representative as can be attained. The tensile piece should reproduce, with some degree of similitude, size and molding conditions corresponding with those of the casting parts which are subjected to tensile stress. The transverse-bar in size and molding conditions should represent approximately those parts which are to be loaded transversely. This is frequently very difficult to attain in case of the cast-on bars. Often test pieces cannot be placed where they should, but must be placed where they can. Casting strength itself may suffer by reason of the presence of a cast-on bar. The writer says that the cast-off bar can be made at least as representative of the casting as is possible in the case of the attached test piece. Kz (9b)

Apparatus for Tensile Testing at Low Temperatures (Dispositif pour essais de résistance à la traction à basse température). *Genie Civil,* Vol. 104, Jan. 27, 1934, pages 90-91. Amsler tensile testing machine is provided with 2 concentric cylindrical receptacles. The inner cylinder contains the usual threaded specimens with their grips and is filled with alcohol. The outer, connected at the bottom with the first, is filled with solid CO_2 and closed at the top. Evaporating CO_2 bubbles through alcohol stirring it and keeping the temperature uniform. JDG (9b)

Static Tensile Tests With Rods of Gray Iron Having Long Holes (Statische Zerreisversuche mit Langlochstäben aus Grauguss). Julius Bach. *Die Giesserei,* Vol. 21, Oct. 12, 1934, pages 429-432. The stress distribution in the endangered section of a rod which is joined to other parts by a wedge transverse to its axis (as in crossheads, piston rods) was investigated with rods cast vertically and having holes for wedges of different dimensions. The load which leads to fracture is related to the ratio of length to width of the wedge slot; if the edges of the slot are not rounded the resistance against fracture is lowered about 13%. For usual ratios of thickness of wedge to diam. of rod (d/3 to d/4) the chance of fracture occurring at the long side of the wedge slot or at the small side is about equal. A formula for the maximum load was derived: $P=0.223\ d^2 K_z$, where d is diam. of rod in cm. and K_z tensile strength of gray iron, which can be assumed to be 2000 kg./cm.^{2}. Suggestions for dimensioning such connections properly and applications of the test also for steel rods are discussed. Ha (9b)

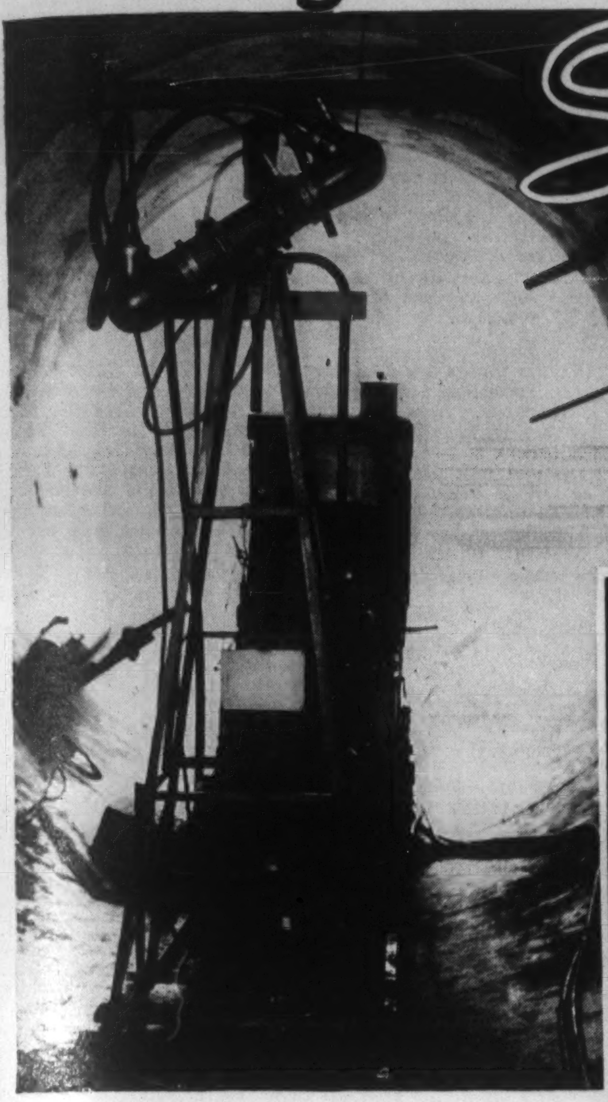
Continuation of Breaking Tests of Structures of Composite Sections with Low Slenderness (Voortzetting van knikproeven van constructies van samengestelde doorsnede met geringe slankheid). M. G. Driessen. *De Ingenieur,* Vol. 49, Aug. 10, 1934, pages A.297-A.301. Further tests to determine the breaking (collapsing) resistance of columns of composite sections are reported. By reducing the slenderness of structures held on both ends, no increase of resistance is obtained. If the ratio breaking load to flow limit is plotted as function of slenderness it remains constant from a ratio of 12 to almost 45 and equal to 1, the greatest deviation being about 7% in either direction. An increase of load after exceeding the breaking limit for very short (and practically not often used) columns (ratio about 12) shows that the effective section of the material is increased by the upsetting effect. A very rapid increase of pressure of short bars or columns causes an apparent increase of breaking strength. The results are discussed with respect to practical utilization in shaping of columns and equalization of stresses over the section by boring. Ha (9b)

Wall Thickness Sensitivity of Machined Gray Cast Iron Test Bars and Its Relation to Analysis (Die Wandstärkenempfindlichkeit getrennt gegosse er Probestäbe und ihre Beziehung zur Analyse). P. A. Heller & H. Jungbluth. *Technische Mitteilungen Krupp,* Vol. 2, Sept. 1934, pages 106-116. On turned cast test bars of circular cross section it was shown an exponential relation exists between tensile strength and wall thickness, which makes it possible to express wall thickness sensitivity by means of a numerical coefficient in a simple way. It can also be shown that this coefficient can be calculated from the sum of the C and Si contents, and that within narrow limits the strength of a casting of a given wall thickness may be calculated, provided the test bars are simple cylinders and an unalloyed iron is melted and cast following the usual practice. Studied hardness and bend tests without succeeding in establishing any clear correlation. Calculates table for conversion from standard American test bar to standard German bars of values of tensile strength and bend test. MG (9b)

New S. K. Friction Testing Machine and its Test Results. (Chiefly on the Lubricated Friction). Shirô Kusunose & Hideo Nakamura. *Journal Society of Mechanical Engineers,* Vol. 37, Mar. 1934, pages 143-151. In Japanese. Viscosity seems most directly concerned in an effective and efficient operation of machinery. However this property of oils did not exhibit the same results in lubrication tests with different metals. The authors show the necessity for a more effective means of determining the character of friction and lubricants. Discussion of a friction testing machine and tests carried out. Three kinds of bearing metals (white metal, Pb bronze, gun metal) and a steel ring were chosen as specimens. Composition and mechanical properties are tabulated. Diagrams show the limit of safety for the oils and metals used in the tests under the various test conditions. The authors point out that "oiliness," as they call it, becomes a very important property as a factor in lubrication, which depends to a certain degree upon the kind of metals forming the sliding surfaces. It is shown that the same lubricant gives different results according to the metals used in the test. Kz (9b)

A New Method of Surface Testing (Eine neue Methode der Oberflächenprüfung). A. Kufferath. *Oberflächentechnik,* Vol. 21, Oct. 9, 1934, pages 211-213. A microscope for comparison of a highly polished surface with a standard surface is described which can be placed directly on the surface to be examined. It is explained how quality of welds, formation of cracks, fibers and lacquer surfaces can be easily observed. Ha (9b)

Chicago Bridge and Iron Works *Selects* G-E X-RAY UNIT for TVA Project



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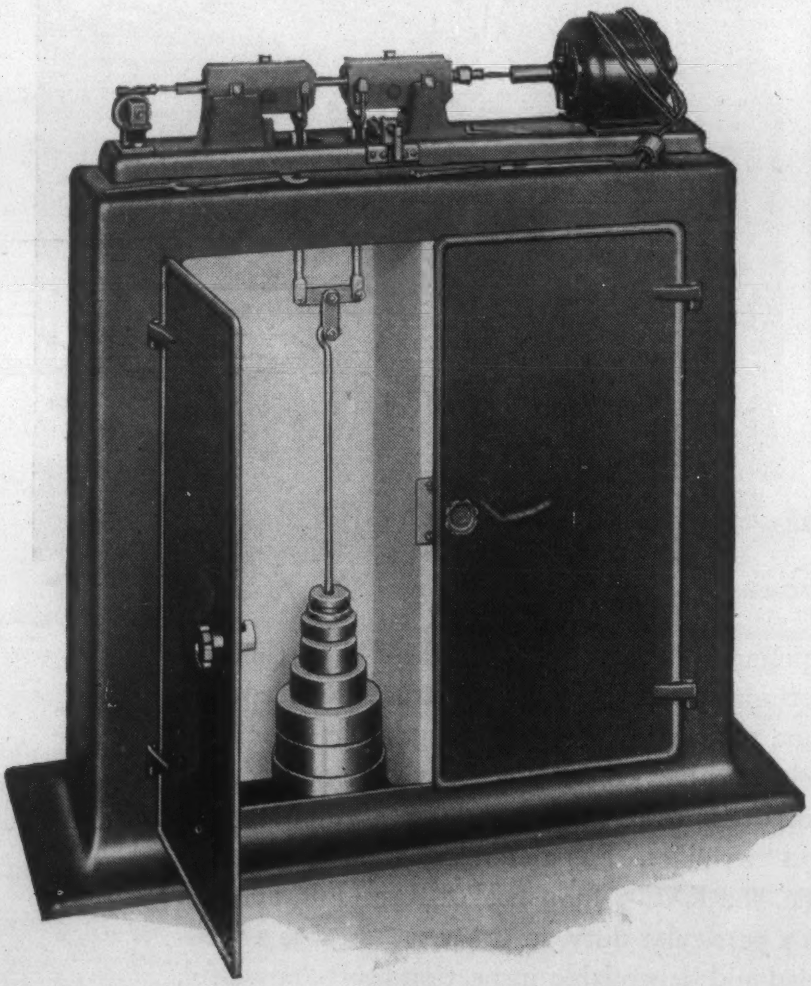

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Investigations on Deep Drawing (Untersuchungen über das Tiefziehen). L. Hermann & G. Sachs. *Metallwirtschaft,* Vol. 13, Oct. 5, 1934, pages 687-692. Oct. 12, pages 705-710. Deep drawing tests were made on a Wazau tester, using fully annealed sheet brass, 63% Cu, from .1 to 2.0 mm. thick. Varying the force holding down the sample and radius of the drawing ring was found to have practically no effect on the tearing strength. However the tearing strength increases as the radius of the plunger is increased, with a max. at 10 mm. radius, then it decreases slightly with further increase in radius. With increasing thickness of the sheet the tearing strength decreases considerably. The ratio of tearing strength to tensile strength, using the same plunger radius, is the same for widely different materials, such as brass and V2A stainless steel. A formula is given for the max. tearing strength in relation to thickness of sheet and plunger radius, which holds good for any material. The applied drawing force is affected by those factors which do not influence the tearing strength. The relation between applied force and diam. of the sample, radius of drawing ring, plunger radius, and the force holding down the sample is shown in graphs. If the holding force is too small, wrinkles form and additional drawing force is required to flatten them out. The effect of various factors on the holding force was investigated. The optimum holding force depends especially on the sheet thickness and diam. of sample. The plunger radius does not affect the area of the cup formed, but a greater radius produces a deeper cup. Both area and depth of cup increase as the drawing ring radius is decreased. 38 references. CEM (9b)

Determination of Tensile Strength of Cast Iron by Means of the Wedge-Pressure Test (Bestimmung der Zugfestigkeit von Gusseisen mittels der Keildruckprobe). P. Ludwik & J. Krystof. *Die Giesserei,* Vol. 21, Oct. 12, 1934, pages 432-435. The suggestion is made to replace the tensile test for cast Fe in cases where it is too tedious and costly as in many routine operations, by a new "wedge-pressure" method in which a specimen of only 5 cm. length and 1 cm.^{2} section (round or square) is placed between 2 hardened, vertically movable steel wedges which are pressed together until the specimen breaks. This method requires only a press with indication of the pressure exerted. The maximum load referred to the section is a measure of the tensile strength for un-alloyed and un-heat-treated cast Fe. The tensile strength is from 20 to 50% higher than the maximum load found in this test. Ha (9b)

Fatigue Testing (9c)

H. F. MOORE, SECTION EDITOR

The abstracts appearing under this heading are prepared in coöperation with the A.S.T.M. Research Committee on Fatigue of Metals.

The Development of Slip Lines and Fatigue Cracks under Repeated Stresses in Low and High Carbon Steels Welded by the Butt-Welding Method (Flash Weld). Tibor Ver. *Iron & Steel Institute, Carnegie Scholarship Memoirs,* Vol. 22, 1933, pages 135-156. Seven carbon steels containing 0.05 to 0.86% carbon were used in the electric butt weld experiments. Tensile strength was greater at the welds. Hardness, especially in the higher carbon steels was equal to or lower than that of the unwelded material. The endurance limits were a function of the development of the ferrite network in the welded portions. Slip lines occurred in the Widmanstätten structure of the low carbon steels with greater difficulty than in the normal grained structure of the unwelded zone. In the higher carbon steels the ferrite network of the welded portion favored the spread of fatigue cracks. Fatigue cracks showed a tendency to develop and spread during tests in previously formed slip lines of ferrite network or to appear in a direction in which slip lines were subsequently formed. The endurance limit of welded materials tend to rise if the development of ferrite network is prevented by shortening the time of welding, or by using suitable alloy steels. . Cracks started by static test may develop in the ferrite network. No references. CW (9c)

Increase of Endurance Strength of Notched Structural Parts by Internal Stresses (Steigerung der Dauerhaltbarkeit gekerbter Konstruktionsteile durch Eigenspannungen). A. Thum & W. Bautz. *Zeitschrift Verein deutscher Ingenieure,* Vol. 78, Aug. 4, 1934, pages 921-925. Artificially produced internal stresses can be used to increase the endurance strength of a material, and in particular of a working piece made of the material, provided that the stresses due to external load are reduced by the internal stresses. The system of internal stresses should be not only uniaxial but lie preferably in the direction of the principal external stresses, and must be produced in a manner as to last during operation. These conditions can best be obtained by cold-deformation whereby the flow-limit of the material is increased in the endangered range. Notches and bores are very suitable to produce multiaxial internal stresses of desired direction and magnitude. Several endurance tests were made to show the influence of pressure employed in cold-deformation and of the shape of the piece on the increase of endurance strength. Static pressure has given better results than impacts or hammering for producing internal stresses. A few practical applications of this method are described. 14 references. Ha (9c)

Investigations on Manhole Bottoms (Untersuchungen an Mannloch-Böden). E. Siebel. *Zeitschrift Verein deutscher Ingenieure,* Vol. 78, Sept. 29, 1934, pages 1149-1150. The investigations were to determine the most favorable form of manhole bottoms with respect to stress distribution. It was found from tests with differently shaped edges of the manhole that by flanging the edge of the hole outward and welding a ring around the flange the strength of the bottom is improved considerably; the ring can serve as seat for the manhole cover. Such bottoms withstood an alternating stress of 200,000 load changes under an interior pressure from 10-60 atm., and of 15,000 alternations from 10-90 atm. internal pressure without failure. Ha (9c)

Study of Endurance Limit Phenomena (Études des Phénomènes de Fatigue dynamique). Rouchet. *Usine,* Vol. 43, July 5, 1934, page 37. Reduction of weight of structures can be obtained not only by superior materials but also by more accurate determination of the endurance limit. Methods of testing to determine the fracture of a metal under variable stresses are discussed, the maximum of which is always lower than the stress at fracture under static conditions. Ha (9c)

Report of Research Committee on Fatigue of Metals. H. F. Moore, Chairman. *Preprint for the June 1934 meeting of the American Society for Testing Materials.* 2 pages. Progress report. VVK (9c)

Fatigue Failure and Crystalline Structures. *Engineering,* Vol. 137, Mar. 9, 1934, pages 298-299. Summary of the third part of a lecture delivered by H. J. Gough before the Royal Institution, Mar. 1934. See "Crystalline Structure in Relation to Failure of Metals," *Metals & Alloys,* Vol. 5, July 1934, page MA 346. LFM (9c)

A High-Speed Fatigue Testing Machine and Some Tests of Speed Effect on Endurance Limit. G. N. KROUSE. *Preprint June 1934 meeting of the American Society for Testing Materials,* 5 pages. The author presents a shorter and less expensive method of determining the endurance limits of materials by the use of a high-speed fatigue testing machine driven by an air turbine, operating over a range of speeds from 5000 to 30,000 r.p.m. and built in the shops of the Materials Testing Laboratory at the University of Illinois. The table gives the results of five tests using different speeds and finishes on each of eight materials. From these results it is shown that up to 10,000 r.p.m. there is no appreciable speed effect when compared with the slower-speed rotating-beam tests. At 30,000 r.p.m. there is an increase in endurance limit varying from 1000 to 6000 lbs./in.^{2} for the longitudinally polished specimen while the endurance limits for the V-notch specimens increased up to 3000 lbs./in.^{2} In each case the stress concentration factor for the V-notch in a given material remained practically constant. Within practical limits the speed effect may be estimated.

Endurance Limits of Specimens Tested at Various Speeds
Endurance Limit, lbs./in.^{2}

Material	Rotating-beam machine	Krouse high-speed cantilever machine				Endurance Limit Ratios	
	1500 r.p.m.	10.000 r.p.m.	30.000 r.p.m.	10,000 r.p.m.	30,000 r.p.m.	10,000 r.p.m.	30,000 r.p.m.
	Polished Specimen			V-Notch Specimen			
S.A.E. No. 1020 steel	31,000	31,000	33,000	22,000	25,000	1.41	1.32
Stainless steel	60,000[a]	63,000	69,000	26,000	28,000	2.42	2.47
S.A.E. No. 4140 steel	98,000	99,000	102,000	46,000	47,000	2.15	2.21
	79,000[a]						
Rail steel	50,000	50,000	51,000	26,000	27,000	1.92	1.89
Gray cast iron	10,000	10,000	11,000	13,000[c]	13,000	0.77	0.85
Alloy cast iron	26,000	26,000	29,000	22,000	24,000	1.18	1.20
Brass[b]	20,000	24,000	27,000	12,000	13,000	2.00	2.08
Duralumin[b]	15,000	15,000	17,000	12,000	13,000	1.25	1.31

[a] Transverse polish. It has been found on several occasions that certain materials have their endurance limits markedly decreased by a transverse polish.

[b] Endurance limits on basis of 50,000,000 cycles (endurance limit for duralumin decidedly lower for 5 x 10^8 cycles.)

[c] The increased endurance limit for the notched gray cast iron has been carefully rechecked.

VVK (9c)

Fatigue-Testing Machine for Wire. *Engineer,* Vol. 158, Aug. 17, 1934, pages 167-168; *Engineering,* Vol. 138, Aug. 10, 1934, pages 139-140. Brief description of machine designed at the Royal Naval College, Greenwich, by B. P. Haigh and T. S. Robertson, and now manufactured by Bruntons, Ltd., Musselburgh, Scotland. With this machine the specimen is gripped and loaded in such a manner that the fracture occurs in the middle far from the grips. It is possible to make tests on wire with the hard-drawn skin intact just as it comes from the die. It may be galvanized, plated, rusted, or otherwise injured, treated with a preservative or a corrosive agent. Thus the specimen can be tested under conditions very similar to that encountered in actual service. One end of the wire is gripped in a chuck while the other runs in a special form of ball thrust bearing. The latter moves towards the chuck, bending the wire and the chuck turns about on a vertical axis. This causes the wire to bend in a horizontal plane under the action of two equal and opposite forces. The speed of rotation is 20 million cycles in 24 hr. while with small-gage wire it is possible to reach a speed of 28 million cycles. A photograph of the machine is given as well as diagrams and a graph showing the results of actual tests. LFM (9c)

Electric Drive of Fatigue Bending Machines (Der elektrische Antrieb von Dauerbiegeschwingmaschienen). R. BAUDER & H. MACKH. *Elektrotechnik & Maschinenbau,* Vol. 52, Sept. 9, 1934, pages 423-425. Describes testing machines with grid-controlled ion tubes for control and supervision of the operation of the machine. Ha (9c)

Influence of a Tight-Fitting Bolt on the Endurance Strength of a Drilled Rod (Einfluss eines eingepassten Bolzens auf die Dauerfestigkeit eines gebohrten Stabes). E. SIEBEL & E. KOPF. *Zeitschrift Verein deutscher Ingenieure,* Vol. 78, July 28, 1934, pages 918-919. The (theoretical) tension on the edges of a bore through a flat bar is 3 times that of the full section. Tests showed that this can be reduced if a tight fitting bolt is inserted in the hole after the bar has been stressed to the maximum load occurring in service. When the stress is lifted a stress is superimposed upon the original stresses which is entirely uniform, bar and bolt acting now as one piece. The stress at edge of the bore is reduced to about 1/3, so that the endurance (fatigue) strength is considerably increased. Holes in structural parts can be closed and their influence diminished in this manner. Ha (9c)

Fatigue Strength of Cast Iron and Its Relation to Structure and Surface Quality (Die Schwingungsfestigkeit von Gusseisen und ihre Beziehungen zum Aufbau und zur Oberflächenbeschaffenheit). C. PFANNENSCHMIDT. *Die Giesserei,* Vol. 21, May 25, 1934, pages 223-228; June 8, 1934, pages 243-245. Castings of different age and made by different methods were subjected to tensile and bending endurance tests in order to find eventual effects of surface quality due to different machining methods. Some of the examined castings were older than 25 years, the samples consisted of ordinary and alloy cast irons. The general conclusions derived from the tests which are given in charts and microphotographs, can be summarized as follows: If the composition of a casting is adapted to its respective purpose and shape, endurance strengths can be obtained, even in constructively unfavorable green sand castings, of 15 kg/mm^2. The ratio of fatigue strength to tensile strength is not constant, it is, for non-alloyed materials, between 0.45-0.5, for alloyed materials it can increase to 0.8 but is, in average, 0.55-0.65. Pronouncedly brittle materials, e.g. Cr-alloy cast irons, are below the average but can not be considered as belonging in such a series owing to the high content of bound C. Non-alloyed grey Fe showed a percentage gain in flexural endurance limit which seemed to be correlated with the condition of graphite formation. The smaller the "interior" notch effect is (i.e. under a more favorable graphite formation) the higher the flexural endurance limit. Relations of static to endurance bending strength could not be established. 10 references. Ha (9c)

Fatigue Tests on Steel Wires Under Pulsating Tensile Stress (Dauerprüfung von Stahldrähten unter wechselnder Zugbeanspruchung). ANTON POMP & MAX HEMPEL. *Die Naturwissenschaften,* Vol. 22, June 1, 1934, pages 398-400. The improved testing machine developed in the Kaiser Wilhelm Institut für Eisenforschung is described and the experimental results on steel wires treated in different manners but to the same strength are given. The experiments are carried out in air and under the corroding influence of tap water. In the latter case a drastic reduction of the fatigue strength of 45.5% confirms earlier American and German investigations. EF (9c)

Corrosion Fatigue and Sucker-Rod Failures. BLAINE B. WESCOTT & C. NORMAN BOWERS. *Proceedings American Petroleum Institute,* Vol. 14 (IV), 1933, pages 29-38. See *Metals & Alloys,* Vol. 5, July 1934, page MA 346. VVK (9c)

METALLOGRAPHY (10)

J. S. MARSH, SECTION EDITOR

The Structure of Calcium Boride CaB_6. LINIUS PAULING & SIDNEY WEINBAUM. *Zeitschrift für Kristallographie, Kristallgeometrie, Kristallphysik, Kristallchemie,* Vol. 87, Jan. 1934, pages 181-182. In English. Verifying the results of Stackelsberg & Neumann, the unit cubic cell CaB_6 is shown to have $a_0 = 4.145 \pm 0.005$ A.U. and to contain Ca at ½½½, 6 B at $\pm$ 00 u. The accurately determined value of the parameter $u = 0.293 \pm 0.001$ makes each boron atom equidistant from 5 others, the boron-boron separation being 1.716 A.U. EF (10)

The Structure of Tin Bronzes (Der Aufbau der Zinnbronzen). J. VEROE. *Zeitschrift für anorganische und allgemeine Chemie,* Vol. 218, July 14, 1934, pages 402-428. It is pointed out that the practically most important alloy systems have complicated structures, a fact to which they owe their very varied properties. Literature since 1922 is reviewed and recent investigations are described to determine again exactly the range of 12-38% Sn in order to clarify some existing discrepancies. A new diagram was developed which, together with thermal and microscopic examinations in that range, showed that 3 peritectic horizontals exist for the reactions: $\alpha + L \longrightarrow \beta$ at 797° C., $\beta + L \longrightarrow \gamma$ at 756°, and $\gamma + L \longrightarrow \phi$ at 742°. The solubility of Sn in Cu amounts to 13.3% at 795°, 16% at 586-520°, and 14% at room temperature. The horizontal 586° in the $\alpha + \beta$ range has a very close connection with the eutectoid disintegration of β into $\alpha + \gamma$. The results of Hamasumi and Nishigori with regard to transformations in solid state of alloys with 30 to 38% Sn were confirmed (*Tech. Reports, Tohoku Imperial University,* Vol. 10, 1931, page 131). Solidification of the compound Cu_3Sn takes place in a temperature interval of 2-3°. The discontinuity in the change of resistance at 600° in the alloys is not due to a transformation similar to A_2 but must be attributed to disintegration. 26 references. Ha (10)

Contribution to the Study of Morphological Heredity Phenomena in Hypo-Eutectoid Steels (Contribution à l'Étude des Phénomènes d'Héredité morphologique dans les Aciers hypo-eutectoides). PIERRE KERSTEN. *Revue Universelle des Mines,* Series 8, Vol. 10. July 1, 1934, pages 341-347, July 15, 1934, pages 369-375, Aug. 1, 1934, pages 408-412. A piece of steel will, in spite of having been subjected to a cycle of careful mechanical and thermal treatment, nevertheless conserve traces of its origin and production processes. Chemically and physically pure metals which have been carefully produced should, theoretically, not present any heredity phenomenon; the latter can nevertheless manifest itself if the normalization temperature was insufficient; that is to say, wrong or defective preliminary heat-treatment can cause, in a sound and normal metal, the same phenomenon as is met in a metal of inferior quality. For details of the investigation the original must be referred to. Ha (10)

Investigations of the Equilibria of Iron and Oxygen with Silicon, Calcium and Phosphorus as Contribution to the Question of Slag Inclusions in Steel (Untersuchungen über die Gleichgewichte des Eisens und Sauerstoffs mit Silizium, Kalzium und Phosphor als Beitrag zur Frage der Schlackeneinschlüsse im Stahl). F. KANZ. *Mitteilungen aus dem Forschungs-Institut Vereinigte Stahlwerke Aktiengesellschaft Dortmund,* Vol. 4, Jan. 1934, pages 1-22. In order to clear up the nature of non-metallic inclusions which may occur in steel, the structure in the Fe-corner of the Fe-O system with Si, Ca, or P was determined for the phases occurring at room temperature. Slag inclusions in steel can occur as ferrous oxide, fayalite, SiO_2, calcium-orthoferrite 2CaO. Fe_2O_3, lime, and iron-phosphate $Fe_2P_2O_7$. 34 references. Ha (10)

X-Ray Studies of Transformations of Cr-Ni Steel (Étude Roentgenométrique des Transformations de l'acier au chrome-nickel). J. SPLICHAL & F. CABICAR. *Collection of Czechoslovak Chemical Communications,* Vol. 6, June 1934, pages 251-268. A Cr-Ni steel (0.46% C, 0.57% Mn, 0.36% Si, 0.009% P, 0.006% S, 0.88% Cr, 3.14% Ni) was subjected to different heat treatments and X-rayed (Debye-Scherrer method), the anticathode being iron. The grain size was determined by means of Brill's equation. A sample containing 0.30% C, 0.74% Cr, 3.03% Ni, and 1 mm. in diam., when heated to 900° C. and then cooled at a speed of 300° C. per hr. to 450° C., then water quenched, produced martensite I and secondary troosite microstructures. X-ray analysis gave a = 2.855 A. U., C = 2.89 A. U. and $\frac{c}{a} = 1.012$. Other Ni-Cr steel samples had 0.46% C, 0.88% Cr, 3.04% Ni. Sample I, 0.5 mm. in diam., heated to 850° C. and furnace cooled at about 50° C. per hr., gave pearlite and a = 2.88 A. U. Sample II, 0.5 mm. diam. heated to 850° C. and air cooled, resulted in austenite and in tetragonal martensite (martensite I). Sample III, 0.5 mm. in diam., water quenched from 850° C., showed martensite II (austenite and tetragonal martensite). Austenite dimensions were a = 3.61 A. U. and the grain size was 7.29 A. U. Sample IV, 0.5 mm. diam. heated to 1000° C., cooled at a speed of 400° per hr. and water quenched from 400° resulted in decomposed martensite I and martensite II. The austenite dimensions were $a_0 = 3.57$ A. U., the grain size was 895 A. U. Sample V, 0.5 mm. diam., heated to 1000° C., then cooled 400° per hour and water quenched from 480°, showed non-decomposed martensite I and martensite II with grain size 1235 A.U. Sample VI, 1 mm. diam. was heated to 900° C., cooled at speed of about 300° per hour to 450°, then water quenched. The structure consisted of decomposed primary martensite and the secondary martensite. The grain size was 910 A. U. Spectrograms at high temperatures were taken of 0.6 mm. diam. samples, tested at 900° C., 800° and 750° respectively at temperatures 900° to 800°. There was observed a solid solution of γ-Fe, while at 750° 2 phases, α and γ were observed. 18 references. GTM (10)

The Effect of Chemical Composition and Grain Size on Precipitation Hardening (Über den Einfluss der chemischen Zusammensetzung und der Korngrösse auf die Ausscheidungshärtung). E. SÖHNCHEN. *Metallwirtschaft,* Vol. 13, Sept. 21, 1934, pages 655-661. A lecture. The latest contributions to the theory of precipitation hardening are reviewed. According to them the process consists of 3 separate steps. The effect of adding a third metal to a binary system is to change either the magnitude or the speed of precipitation hardening. These changes are caused by the effect of the third element on the solubility in the binary system. The effect of Si, Mn, V, Ni and Co on the hardening action at 400° to 700°C. of 1% Cu in low carbon steel is shown graphically. The effect of Fe, Si, Ag, Mn, and Ti on Cu-Be alloys, of Si, Fe and Mg on the hardening speed of Al-Cu alloys, and of C on the hardening speed of Cu steels are given. The influence of grain size on the degree and rate of hardening of several Al alloys was determined. The grain size was varied in the cast alloys by changing the type of mold and in the rolled alloys by the amount of cold reduction. In every case decrease in grain size caused an increase in the amount and rate of precipitation hardening. The theoretical explanation of the grain size effect in single crystals and polycrystalline materials is discussed by reference to recent investigations. 24 references. CEM (10)

Universal Camera and Self-Indexing Rotating Crystal Camera (Universalkamera und "selbstindizierende" Drehkristallkamera). ERWIN SAUTER. *Zeitschrift für physikalische Chemie,* Abt. B, Vol. 23, Dec. 1933, pages 370-378. Construction and operation of the author's universal camera are discussed. Being used as an X-ray goniometer, the camera represents a type of self-indexing rotating-crystal camera, since the special case is realized that interferences appear in such a layer-plane-like fashion of "perfect" lattice-plane diagrams that by intelligent superimposing of the plane lattices an interference space lattice analogous to a reciprocal lattice of ½ λ H can be secured. EF (10)

Crystal Alignment in Drawn Brass Cups (Kristallgleichrichtung in gezogenen Messingbechern). L. HERMANN & G. SACHS. *Metallwirtschaft,* Vol. 13, Oct. 26, 1934, pages 745-752. Cups were deep drawn from annealed sheet brass, containing 63% Cu. Samples for X-ray examination were taken from 9 different locations, from the rim to the bottom, to study the effect of cold working in all 3 directions. Each sample was examined from 12 to 16 different directions and examples of diffraction patterns and pole figures are given. The state of deformation was determined on the 9 samples and varied from +1, ordinary axial compression, through 0 to almost —1, ordinary axial elongation. The diffraction patterns disclose distinct equi-directional properties of the crystals in all zones and the pole figures show that some of the structures are almost fiber structures. At the rim of the cup there is an almost complete fiber structure with the tangential direction as fiber axis. The fiber axis is the diagonal of a plane [110] of the regular face centered brass lattice. At the center of the bottom of the cup, corresponding to pure axial compression, a complete fiber structure is obtained, with the normal direction as fiber axis, again in the [110] direction of the lattice. The structure is determined by the type of deformation and is independent of the type of stress. Near the lower end of the straight side of the cup the deformation corresponds to elongation, and the fiber structure is not quite complete. The fiber axis is the radial direction, corresponding partly to a [111] and partly to a [200] direction of the lattice. The structures of the intermediate zones are a combination of the "compression" and "elongation structures." At the 2 points where the deformation is 0, the structure is identical, although the stresses producing this state were quite different. 21 references. CEM (10)

Methods for the Study of Crystal Powders by Electron Diffraction (Methodisches zur Untersuchung von Kristallpulvern mittels Elektronenbeugung). FERDINAND TRENDELENBURG & OTTO WIELAND. *Wissenschaftliche Veröffentlichungen aus dem Siemens-Konzern,* Vol. 13, Nov. 15, 1933, pages 41-47. Describes apparatus for carrying out diffraction studies with electrons of moderate velocity (about 30 KV) on powdered materials. An advantageous method for introducing the substance into the electron stream is described. Discusses the accuracy attained in measuring interplanar distances (the average error in individual measurements with sharp Debye-Scherrer rings is around 0.25%). Various materials (carbonaceous materials, aluminum silicates like clay, agalmatolith, pyrophyllith and others) were studied with this apparatus. Photograms are reproduced. MG (10)

Investigation of the Heat of Transformation and the Change in Some Physical Properties at the Transformation of β-Brass (Untersuchungen über die Warmetönung und die Änderung einiger physikalischer Eigenschaften bei der Umwandlung des β-Messings). H. VON STEINWEHR & A. SCHULZE. *Zeitschrift für Metallkunde,* Vol. 26, June 1934, pages 130-135. The heat of transformation of β-brass was found to be 3.0 calories per gram, the transformation occurring over a definite temperature interval of 430° to 480°C. A detailed account of the method of measurement, the calculations, and the corrections necessary are given. Additional measurements of the temperature coefficients of thermoelectric force, expansion, and electric conductivity over a wide range of temperature all showed a distinct change at the transformation interval. The reproducibility of the conductivity measurements on rising and falling temperature is taken as a proof of the existence of a temperature interval of transformation. It is concluded that the transformation involves a change from an ordered to a random arrangement of the Zn atoms. FNR (10)

The Exact Measurement of the Specific Heats of Solid Substances at High Temperatures. VII. The Calorimetric Behavior of Zirconium. F. M. JAEGER & W. A. VEENSTRA. *Recueil des Travaux Chimiques des Pays-Bas,* Vol. 53, July 15, 1934, pages 917-932. In English. Tests on crystallized, compressed powder and pulverized Zr. Highly pure Zr is ductile and melts at 2130°C. The phenomena observed during electric measurements and specific-heat determinations are interpreted on the basis of recent assumptions of Dehlinger on the mechanism of phase transitions such as β brass $\rightleftarrows$ α brass, β Co $\rightleftarrows$ α Co and on occurring intermediate phases. The experimenters also noticed similar phenomena in Ce and Cr which are known to exist in 2 distinct modifications. EF (10)

The Exact Measurement of the Specific Heats of Solid Substances at High Temperatures. VI. The Specific Heats of Vanadium, Tantalum, Niobium and Molybdenum. F. M. JAEGER & W. A. VEENSTRA. *Recueil des Travaux Chimiques des Pays-Bas,* Vol. 53, June 15, 1934, pages 677-687. In English. Mean specific heats, true specific heats and atomic heats of V, and true specific heats, atomic heats and quantities of heat developed by Nb, Ta and Mo were experimentally determined over a temperature range of 0°-1600°C. The experimental data collected in 8 tables show that with all these metals there is no indication of a gradual slowing down of the atomic heat curves at higher temperatures. The temperature coefficient of the atomic heat of the homologous elements V, Nb, Ta etc., is the greater the smaller the atomic weight. None of these metals shows any indication of allotropic change nor could any retardation phenomena be observed. EF (10)

Transformations in the Copper Tin Eutectoid Alloys (Die Umwandlungen in den Kupfer-Zinn Eutektoidlegierungen). I. ISAITSCHEW & G. KURDJUMOV. *Physikalische Zeitschrift der Sowjetunion,* Vol. 5, 1934, pages 6-21, 22-30. Part I. Investigation of phenomena during the decomposition of the β phase in Cu-Sn alloys during annealing. The β crystal does not decompose directly into the α and γ phase. An intermediary phase γ' which probably has a cubic cell occurs. The analogy between α-Fe-austenite and α brass — β brass on one hand and the α and β phase in bronze on the other is pointed out. The axes of the γ phase are parallel to those of the β crystal. The parameter of the cubic γ phase lattice determined by layer-line photographs confirms previous determinations by Westgren and Phragmén (a = 17.9 A.U.). The course of the transformations during annealing could not be cleared up entirely. Part II. A study was made of the effect of annealing temperatures upon changes of atomic arrangement, microstructure, and electric resistance of Cu-Sn alloys. The intermediary β' phase occurring during the decomposition of β bronze on annealing is characterized by its ability of being readily etched and by its low electric resistance. The martensite-like intermediary β' phase occurs only under certain quenching conditions and is suppressed when the β phase breaks down during annealing treatments. The investigators found that a temperature increase of 75°C. was required to bring about the structural changes in coarse crystalline samples and single crystals as compared with powder. EF (10)

Contribution to the Precipitation Hardening of Copper-Silver Alloys (Beitrag zur Ausscheidungshärtung von Kupfer-Silber-Legierungen). R. MITSCHE. *Zeitschrift für Metallkunde,* Vol. 26, July 1934, pages 159-160. It was found that room-temperature precipitation hardening of Ag-Cu alloys, containing about the solid-saturation limit of Cu, could be greatly accelerated by a short anneal (10 minutes) at 300°C. The maximum precipitation hardening of the Ag-Cu alloys occurs at a composition near the Cu saturation limit. This observation is similar to that made on Fe-C alloys by KÖSTER (*Archiv für das Eisenhüttenwesen,* Vol. 2, 1929, page 503). FNR (10)

The Hardness of Cementite and of Chromium Carbide Cr_4C_2 (Die Härte des Zementits und des Chromkarbids Cr_4C_2). H. CORNELIUS & H. ESSER. *Archiv für das Eisenhüttenwesen,* Vol. 8, Sept. 1934, pages 125-127. On the assumption that the hardness of 2-phase alloys is proportional to the mean hardness of the 2, the hardness of cementite was extrapolated to be between 660 to 840 Brinell and of Cr_4C_2 to be about 870 Brinell. The hardness was considerably affected by deformation during the test, the higher values being obtained with lighter loads. SE (10)

Detection of Slip Lines in Noble Metals (Die Sichtbarkeit der Gleitlinien bei Edelmetallen). OTTO FEUSSNER. *Metallwirtschaft,* Vol. 13, Sept. 7, 1934, pages 627-628. Bluish, opalescent light reflections have often been observed on the surface of noble metals. By high power microscopic examination of a sheet of very pure Pd which had been bent it was found that they were due to very fine parallel slip lines which diffracted the light. Under the microscope all colors from red to blue could be seen. CEM (10)

Correlation of Equilibrium Relations in Binary Aluminum Alloys of High Purity. WILLIAM L. FINK & H. R. FRECHE. *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 580, *Metals Technology,* Oct. 1934, 14 pages. This is the 16th paper of a series on equilibrium data on Al-rich alloys of high purity. Previously reported data on the systems Al-Fe, Al-Cu, Al-Si, Al-Mg, Al-Mg_2Si, Al-Co, Al-Cr, Al-Mn, and Al-Ni are considered. When the log of the reciprocal of absolute temperature is used for the ordinate and the log of atomic % for abscissa in plotting equilibrium diagrams, solid solubility and hypereutectic liquidus are straight lines as should be the case if the alloys behave as perfect dilute solutions. Except for the systems Al-Mg and Al-Mg_2Si, plot of log of reciprocal of absolute temperature against log of ratio of solubility in liquid to solubility in solid at eutectic temperature yields a straight line as is required if the alloys obey the laws of dilute solutions. A number of empiric relationships are developed. It is concluded that diagrams drawn from a very few accurately determined points on the basis of thermodynamic relationships are likely to be more accurate than diagrams drawn with the aid of many points determined less accurately or with impure alloys. 49 references. JLG (10)

Further Investigations with the Optical Dilatometer of Bollenrath (Weitere Untersuchungen mit dem optischen Dilatometer nach Bollenrath). W. KOCH. *Metallwirtschaft,* Vol. 13, Sept. 28, 1934, pages 671-672. The optical differential dilatometer of Bollenrath is described. Accurate results are obtained if the temperature is increased evenly and slowly, by raising the current .05 amp./5 min., and by carefully placing the test specimen in the improved tube. Tests on pure Bi, using Al for comparison, show that the allotropic transformation at 75°C. reported by others does not exist. CEM (10)

Latent Energy Due to Lattice Distortion of Cold-Worked Copper. W. A. WOOD. *London, Edinburgh, & Dublin Philosophical Magazine & Journal of Science,* Vol. 18, Sept. 1934, pages 495-505. Lattice distortions produced during plastic deformation were determined by measuring lattice dimensions before and after cold-working and compared with normal Cu by X-ray examination. An irregular expansion of the lattice was found to be produced by the process of working which is interpreted in terms of the equivalent heat energy which would be required to produce a similar state; it is suggested to define this as latent energy due to lattice distortion. 3 references. Ha (10)

New Iron-Carbon Diagram for Steels and Some of its Consequences (Un nouveau diagramme fer-carbone pour les aciers et quelques-unes de ses conséquences). J. SEIGLE. *Génie Civil,* Vol. 104, May 1934, pages 446-449, 465-467. Assuming the existence of α-γ state of Fe intermediate between α stable at room temperature and γ stable at high temperatures changes the shape of the usual Fe-C diagram. To the conception of low C solubility in α and high solubility in γ irons must be added an intermediate solubility in α-γ mixture. Fe remains in α-γ state between Ac_1 and Ac_3 on heating and between Ar_3 and Ar_1 on cooling. The line connecting 0% C at 900° C. with 0.90% C at 710° C. of the generally accepted diagram occupies different positions with varying carbon contents, as was shown by dilatometric studies. Original article must be referred to for diagrams. JDG (10)

The Significance of the Grain Size of Metals. HOWARD SCOTT. *Industrial Heating,* Nov. 1934, pages 111-114, 118. Summary of the American Society for Metals grain-size symposium. Ha (10)

Internal cracks in steels (Cricche interne degli acciai). A. SCORTECCI. *La Metallurgia Italiana,* Vol. 26, Sept. 1934, pages 690-704. Internal cracks in steels are formed largely during forging. They may be reduced to a minimum by carrying out all the processes in which segregation may take place with the utmost care. Thus the operations of deoxidation, decantation of slag, pouring, and cooling, should all be carefully controlled. As to forging, operations should be carried out at the optimum temperature, and cooling carried out at the slowest rate consistent with good practice for the particular steel. AWC (10)

A Simple Camera for X-ray Crystal Structure Analysis of Coarse-Crystalline Material (Eine einfache Kamera für Röntgen-Strukturanalysen von grobkristallinem Material). E. SCHWARZ. *Physikalische Zeitschrift der Sowjetunion,* Vol. 5, 1934, No. 3, pages 443-445. The shortcomings of X-ray powder method are pointed out, the cameras designed by Sachs & Weerts, and Möller are discussed, and a new camera is introduced which, due to proper rotation of the mounted sample in the center of a curved film, permits the recording of all interference lines. Tests on single crystals of metals showed a uniform blackening of all reflection lines, as experienced with fine-grain material. EF (10)

The Crystal Structure of the Compounds $LaMg_3$, $CeMg_3$, and $PrMg_3$ (La struttura cristalline dei composti $LaMg_3$, $CeMg_3$, en $PrMg_3$). A. ROSSI & A. IANDELLI. *Atti accademia Lincei,* Vol. 19, March 1934, pages 415-420. The Crystal structure of $LaMg_3$, $CeMg_3$, and $PrMg_3$, has been determined by the powder method, using a Cu anticathode. The dimensions of the side and the density of the lattices were found to be 7.478 A.U., and 3.27 for $LaMg_3$; 7.37 A.U. and 3.32 for $CeMg_3$; and 7.37 A.U. and 3.46 for $PrMg_3$. Crystallographic data are included, as well as a diagram of the probable lattice structure. AWC (10)

Primary Structure of Gray Cast Iron (Das Primärgefüge des grauen Gusseisens). F. ROLL. *Archiv für das Eisenhüttenwesen,* Vol. 8, Sept. 1934, pages 129-130. There are 2 types of primary structure in cast iron, dendritic or coarsely angular, and finely globular. These differences may not be readily observed in the fracture or even by deep etching or microscopic examination. They can be clearly revealed by sulphur prints, however, as shown by typical prints. SE (10)

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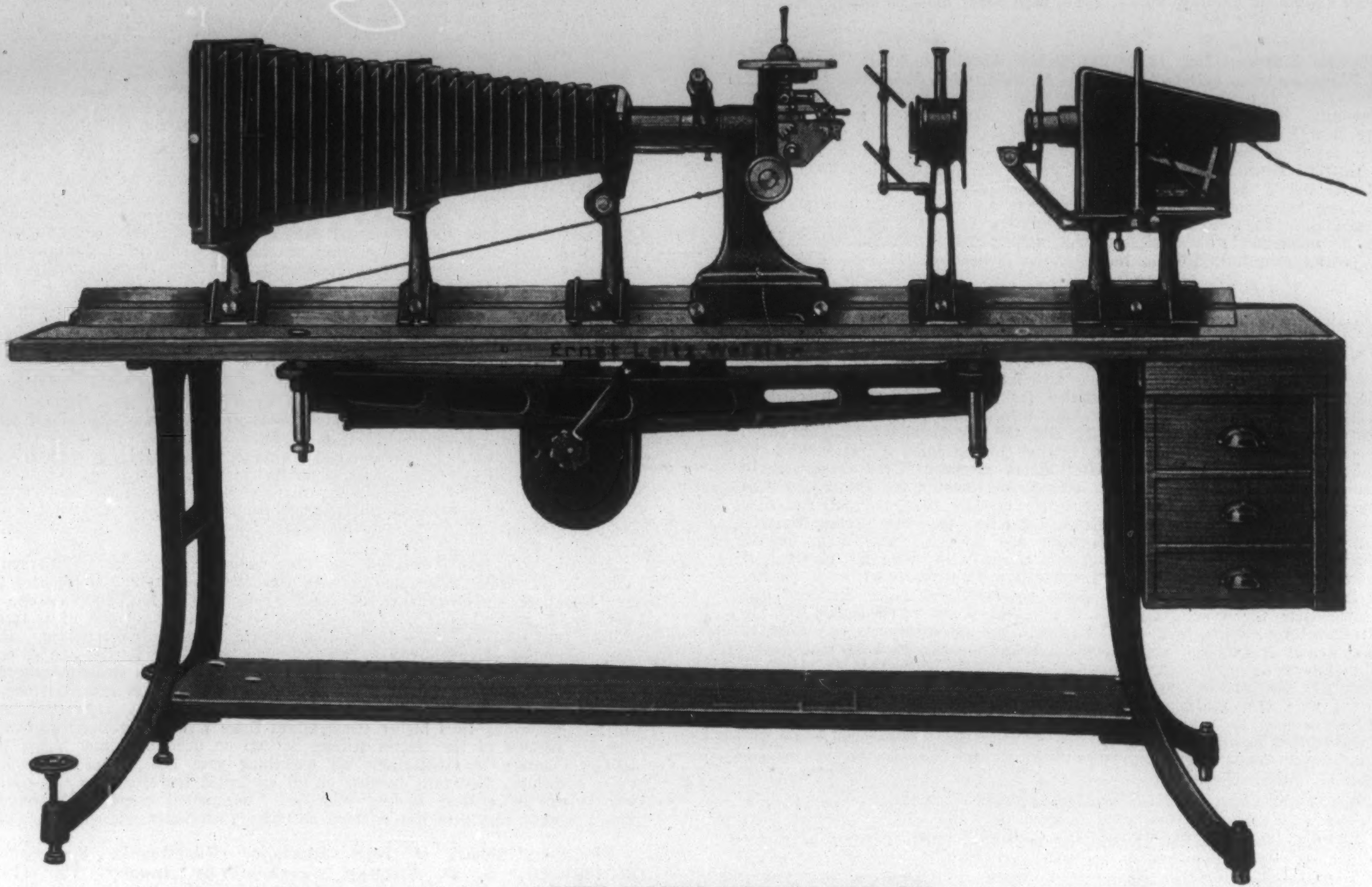

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The System Silica-alumina. (Il sistemo silice- allumina). Orazio Rebuffat. *Giornale di chimica industriale e applicata,* Vol. 16, May 1934, pages 213-215. The equilibria of the system SiO_2-Al_2O_3 have been determined. Tridymite, sillimanite, and dehydrated kaolinite were used. The m.p., of tridymite at 1735° C., drops gradually to 1650 at 40% Al_2O_3, then rises suddenly to 1850° at 50% Al_2O_3; then a slower rise to 1870° (62.9 Al_2O_3-37.1 SiO_2), corresponding to the compound, sillimanite. There is then a flat range up to 70% Al_2O_3, then a rise to 1900°, and then to 1970°, for 80 and 90% Al_2O_3. respectively. No evidence of a eutectic at 1550°, as reported by Bowen and Grieg (*Journal American Chemical Society,* Vol. 7, 1924, page 238), could be found. AWC (10)

The System Aluminum-Zinc (Über das System Aluminium-Zink). E. Schmid & G. Wassermann. *Zeitschrift für Metallkunde,* Vol. 26, July 1934, pages 145-150. A redetermination by the X-ray method of the location of the solid solubility boundary of the γ field in the Al-Zn system shows that the solubility rises from 5% at 160°C. to 48% at 350°C. Both the γ and the β phase are found to have a face-centered-cubic structure. The β field may therefore be regarded structurally as a continuation of the γ field. A miscibility gap lies between the β and the γ fields at temperatures below 350°C. The two fields may be united above this temperature, but the evidence on this point remains uncertain. The eutectoid structure occurring upon the separation of the β phase is produced by a strain gradient accompanying diffusion which brings about a general recrystallization of the alloy. 23 references. FNR (10)

Precipitation in Supersaturated Light Metal Alloys (Studien zur Entmischung übersattigter Leichtmetallegierungen). E. Schmid & G. Siebel. *Metallwirtschaft,* Vol. 13, Nov. 2, 1934, pages 765-768. Zn-Mg alloys, with 10% and 4.7% Zn, Al-Mg alloys, with 13.4% and 7.8% Al, and Mg-Al alloys with 18%, 11.5% and 9.8% Mg, were annealed for long periods and quenched in water. The 4.7% Zn and 7.8% Al alloys also included single crystals. All the alloys were then heated at 218° C., and the Mg-Al alloys also at 156°, for various periods, quenched, and the amount of precipitation determined by calculation from lattice measurements after taking precision X-ray diagrams. In every case the rate of precipitation was considerably smaller for the alloys with lower supersaturation and was slower for single crystals than for polycrystalline samples of the same composition. In the Zn-Mg alloys the concentration changed steadily from the supersaturated to the stable and the lines were sharp for all periods of heating. Solid solutions of different concentration were not observed at the same time. In the Al-Mg alloys the transformation proceeded in 2 phases. With increasing time the concentration of the supersaturated phase decreased and at the same time the concentration of the stable phase corresponding to the drawing temperature appears from the beginning. The line sharpness is good at the beginning and at the end of the drawing time, but not good at that period near the disappearance of the supersaturated solid solution. In the Mg-Al alloys all intermediate concentrations appear in addition to the 2 in the Al-Mg alloys. Tensile tests were also made on the alloys in wire form. In most cases the tensile strength and, to a greater degree, the yield point increase, while the elongation decreases rapidly with increase in drawing time, corresponding to the structural changes. This agrees with the theory of the precipitation of a new crystal form of critical dispersion. CEM (10)

An X-ray Study of Orientation Changes in Cold-rolled Single Crystals of Alpha Brass. Carl H. Samans. *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 579, *Metals Technology,* Oct. 1934, 15 pages. Single crystals of 70:30 brass were made by a modified Bridgman method. Slices approximately ⅛ x ½ x 1 in. were rolled to reductions in thickness of 10, 20, and 30%. Orientations were determined before and after rolling by the Davey method. The influence of rolling on 5 different orientations was studied. Orientations found were explained on the basis of "plane parallelepipedal compression" representation of the forces of rolling. The manner of deformation seemed to be similar to that reported by Taylor for pure compression. In rolling α brass single crystals of any possible orientation one of 3 slip systems will be active, depending on the orientation of the plane of rolling. Lattice orientations resulting will lead to a variation of one of the following ideal positions:

Texture	Rolling Plane	Rolling Direction
1	(110)	[112]
2	(110)	[001]
3	(110)	[011]
4	(001)	[010]
5	(112)	[111]

14 references. JLG (10)

Miscibility of the Sulphides of Copper, Lead and Iron with Metallic Lead in the Liquid State (Über die Mischbarkeit der Sulfide von Kupfer, Blei und Eisen mit metallischem Blei im flüssigen Zustande). W. Leitgebel & E. Miksch. *Metall und Erz,* Vol. 31, July 1934, pages 290-293. The tests were made by melting the materials in a graphite crucible under charcoal and N. When Pb is added to FeS or Cu_2S the m.p. of mixture is lowered. FeS + 30% Pb melts at 1000° C., Cu_2S + 7% Pb at 1060°. Greater Pb additions form 2 liquid layers. Pb and PbS do not separate into 2 layers. When Pb was added to PbS + FeS, Pbs + Cu_2S, and Cu_2S + FeS, separations were formed. Constitutional diagrams for the systems Pb-FeS-PbS, Pb-Cu_2S-PbS, and Pb-Cu_2S-FeS were constructed. Less than 5% FeS or Cu_2S added to a homogeneous mixture 50% Pb, 50%PbS caused separation into 2 layers. The lowest m.p. in the system Cu_2S-FeS-PbS is near the binary eutectic PbS-Cu_2S. Microscopic examination shows the presence of only 3 phases, PbS, FeS, and Cu_2S-FeS solid solution. The lowest solubility of Pb in the liquid mixture of the 3 sulphides is near the lowest m.p. of the Cu_2S-PbS system. From there the solubility increases in all directions, the most in the direction of increasing FeS. The information obtained is valuable for refining operations. 8 references. CEM (10)

New Constitutional Diagrams for the Systems Pb-Tl and Pb-Tl-Cd (Neue Zustandschaubilder für die Systeme Pb-Tl und Pb-Tl-Cd). Ernst Jänecke. *Zeitschrift für Metallkunde,* Vol. 26, July 1934, pages 153-155. A critical review of previous constitutional and crystal structure studies on the Pb-Tl system (McMillan & L. Pauling, *Journal American Chemical Society,* Vol. 46, 1926, page 666; Kurnakow & Puschin, *Journal Russian Physical-Chemical Society,* Vol. 32, 1900, page 830, Vol. 34, 1906, page 1146; V. M. Goldschmidt, *Zeitschrift Physikalische Chemie,* Vol. 133, 1928, page 571) has led to the conclusion that this system contains, in addition to the 2 terminal solid-solution series formerly recognized, a third solid-solution field including the composition of the compound $PbTl_2$. The limits of the three solid solution regions are: Pb base, 100-55% Pb; $PbTl_2$ base, 41-20% Pb; and Tl base, 5-0% Pb. The constitutional diagram of the Pb-Tl-Cd system (Clara di Capua, *Gazzetta Chimica Italiana,* Vol. 55, 1925, page 282) has been revised to include a boundary in the liquidus surface separating the Pb and $PbTl_2$ solid solution regions and terminating in an invariant point (liquid + $PbTl_2$ solid solution = Pb solid solution + Cd) at about 260°C. 8 diagrams, 8 references. FNR (10)

Normal and Abnormal Steels. *Iron & Steel Industry,* Vol. 7, Mar. 1934, pages 203-204. Article reviews paper in General Electric Review, Dec. 1933 by G. R. Brophy. See "Personality of Steel," *Metals & Alloys,* Vol. 5, July 1934, page MA 350. CEJ (10)

Influence of a Grain Boundary on the Deformation of a Single Crystal of Zinc. Richard F. Miller. *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 576, *Metals Technology,* Oct. 1934, 9 pages. Zn rods consisting of 1 large single crystal terminated at 1 end by a transverse grain boundary, at the beginning of the polycrystalline portion, were prepared by a modification of the Bridgman method. The rods were etched and then elongated at a temperature of 180° C. The glide layers were outlined on the surface of the samples; by sectioning along the axis and etching, the directions of those in the neighborhood of the crystal boundary could be accurately determined. Only those glide planes that intersected the boundary were influenced by the boundary. It is suggested that the function of a grain boundary is not to increase the resistance to shear of the adjacent crystal, but to decrease the shearing stress action on it. 10 references. JLG (10)

Multiple Laue Spots from Aluminum Crystals. Preliminary Report. A. Komar & W. Obukhoff. *Physikalische Zeitschrift der Sowjetunion,* Vol. 5, 1934, No. 4, pages 634-635. In English. The distribution of intensity along the Laue spots from thick (6 mm.) deformed Al crystals was found to be strongly dependent on the plastic deformation whereas the spots from a thick undeformed crystal were radially elongated and uniformly black. The exterior layers and several layers inside were found to scatter more energy and therefore to be more imperfect than other layers. Laue spots may be due to the reversible or irreversible changes of the perfection of the crystals and also to the focussing in the case of deformed crystals. EF (10)

The System Iron-Nickel-Molybdenum (Das System Eisen-Nickel-Molybdän). W. Käster. *Archiv für das Eisenhüttenwesen,* Vol. 8, Oct. 1934, pages 169-171. The constitution of the ternary system Fe-Ni-Mo was determined up to Mo contents of the compounds $FeMo_2$ and MoNi. Both form an unbroken series of (Θ) solid solutions. The Fe-Mo and Ni-Mo eutectics, and the eutectiferous solid solutions of Fe-Ni go through a transformation in which melt, α, γ, Θ solid solutions form the 3-phase field α, γ, and Θ; this extends down to room temperature. The solid solutions are capable of precipitation hardening. The Curie point of the Fe-Ni alloys is lowered by Mo. SE (10)

Influence of Heat Treatment on the Magnetic Saturation of Carbon Steels (Einfluss der Wärmebehandlung auf die magnetische Sättigung unlegierter Stähle). H. Esser & G. Ostermann. *Archiv für das Eisenhüttenwesen,* Vol. 8, Oct. 1934, pages 173-176. The magnetic saturation of a series of C steels containing from 0.57 to 1.75% C and of a white cast iron was determined. The magnetic saturation of electrolytic Fe was taken to be 22,580 gausses and of cementite as 13,220 gausses. The amount of retained austenite of the steels as affected by C content, quenching temperature, and quenching medium was also determined. The maximum amount of retained austenite resulted on quenching from above the Acm line; on quenching from higher temperatures there was less retained austenite, presumably because of the greater stresses set up on quenching from higher temperatures. Contrary to expectations oil quenching gave less retained austenite than water quenching, apparently because on oil quenching the specimens the cooling rate was below the critical cooling velocity. "Interrupted quenching" according to Bain's method also gave less retained austenite than water quenching. SE (10)

Microscopic Studies of Ingot Structures (Mikroskopiska Undersökningar å Götstrukturer). B. D. Enlund. *Jernkontorets Annaler,* Vol. 118, Aug. 1934, pages 391-438. The purpose of the investigation was to study the development of the solidified structure and its relation to the quality of the steel and to determine the effect of varying the method of carrying through the charge with respect to segregations and slag inclusions. For this purpose, two identical charges of 0.80% carbon were chosen, but one was pushed somewhat harder than the other. Marked segregation phenomena were noted in the slow charge, but this may have been due to the longer tapping time. Chemical analyses verified the conclusions of the microphotographs. The shell of the ingot was more rapidly and evenly etched than the kernel. Hardness tests showed the exterior of somewhat better quality, probably because it was of finer structure. By addition of sulphur, phosphorus, and oxygen, various characteristic structures were obtained, which in conjunction with the chemical analyses, make possible identification of impurities in the steel. Numerous microphotographs are reproduced illustrating the structures. HCD (10)

Metallography of Aluminum and its Alloys (Metallographie des Aluminiums und seiner Legierungen). V. Fuss. Julius Springer Verlag, Berlin, 1934. Paper 6½ x 9½ inches, 219 pages. Price 22.50 RM. This small book, of approximately 200 pages, contains a wealth of information concerning the general metallography of aluminum and its alloys and deserves a place in all metallurgical reference libraries. The text is divided into 2 major sections and an appendix. The first section concerns itself with pure aluminum and general considerations of 2 and 3 component constitutional diagrams. In the second section the author gives up-to-date information concerning some 44 binary and 26 ternary aluminum alloy systems together with present-day concepts of the age-hardening process in some of these alloys. The appendix, of 17 pages, contains brief sections on gaseous and other non-metallic inclusions, corrosion, protective coatings, soldering, welding, grinding, polishing, etching, and testing methods. The book is very adequately illustrated with many diagrams, figures and photomicrographs; however, many of the photomicrographs could hardly be considered as representative of good polishing and etching technique. The author is to be highly commended for his excellent compilation of the very exhaustive bibliography on aluminum and its alloys, contained in this book. Dana W. Smith. (10)—B—

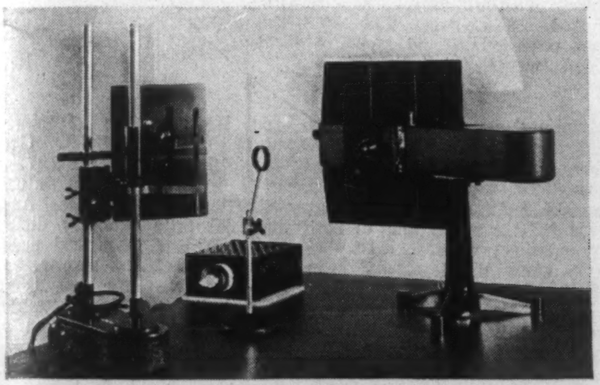
Electron Theory of Metals (Zur Elektronentheorie der Metalle). A. Sommerfeld. *Die Naturwissenschaften,* Vol. 22, Jan. 26, 1934, pages 49-52. Brief review. EF (10)

Results of Crystal Structure Research (Ergebnisse der Kristallstruktur-Forschung). H. Ehrenberg. *Die Giesserei,* Vol. 21, July 20, 1934, page 310. General. Ha (10)

Diffusion in Metals (Diffusion in Metallen). G. von Hevesy & W. Seith. *Metallwirtschaft,* Vol. 13, July 6, 1934, pages 479-484. The rate of diffusion of one metal in another depends not only on the properties of the two metals but also on the phase formed by diffusion. Recrystallization sometimes affects the rate. The simplest case is that of self diffusion, such as the diffusion of two isotopes. The rate of self diffusion is determined mainly by the m.p. of the metal, being much greater for low melting metals. Rates of diffusion which were obtained varied from 0.1 to 10^{-13} $cm.^2$/day. By determining the rate of diffusion at one temperature and interpolating it can be calculated for room temperature. The "heat of dispersion" in diffusion is analogous to the heat of reaction in a chemical reaction. It is determined by the crystallographic properties and is much smaller when diffusion takes place by deposition in the interstices of the lattice, such as the diffusion of Au in Pb and C in Fe, than by exchange of lattice position. The constant A is affected by working of the metal, grain size and impurities. At the same temperature, self diffusion is slower than diffusion of one metal in another and the greater the chemical difference between two metals the higher the diffusion rate. 20 references. CEM (10)

Can you make this analysis Quantitatively ?

Copper	2.5 to 3.5
Aluminum	3.5 to 4.5
Magnesium	0.08 to 1.12
Lead	.007 Max.
Cadmium	.005 Max.
Tin	.005 Max.
Zinc	Remainder



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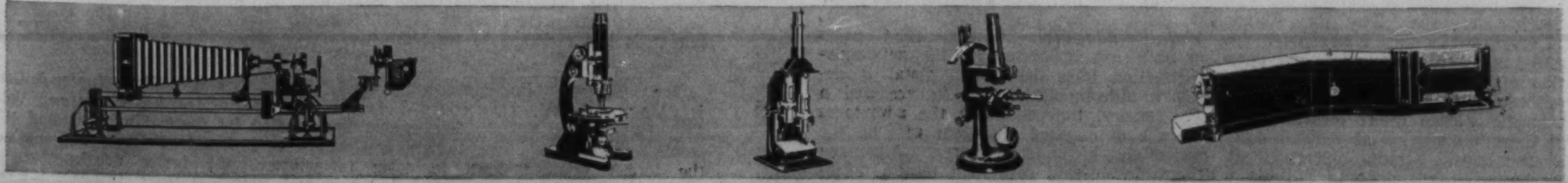

PHOTOMICROGRAPHY • MICROSCOPY • COLORIMETRY • REFRACTOMETRY • SPECTROGRAPHY

The Crystalline State of Thin Spluttered Films of Platinum. G. P. Thomson, Norman Stuart & C. A. Murison. *Proceedings Physical Society,* Vol. 45, May 1933, pages 381-388. Films of platinum spluttered in various gases have been examined with an electron diffraction camera. The indications are that crystals are oriented with one face parallel to the surface of the specimen, but otherwise arranged at random. The crystals are very small, of the order of 5×10^{-7} Cm. JCC (10)

X-ray Investigation into the Compound $MgZn_2$ (Röntgenographische Untersuchung der Verbindung $MgZn_2$). L. Tarschisch, A. T. Titow & F. K. Garjanow. *Physikalische Zeitschrift der Sowjet Union,* Vol. 5, 1934, pages 503-510. The lattice of the compound $MgZn_2$ represents 2 close-packed arrangements wherein the Zn atoms form a hexagonal close-packed structure in which some of the lattice places are unoccupied. EF (10)

Crystal Structure of FeP_2 (Ueber die Kristallstruktur des FeP_2) K. Meisel. *Zeitschrift für anorganische und allgemeine Chemie,* Vol. 218, July 14, 1934, pages 360-364. FeP_2 crystallizes in the rhombic system with $a = 2.72_5$ A.U., $b = 4.97_5$ A.U., $c = 5.65_7$ A.U. The ratio of the axes is similar to that of $FeSb_2$. Ha (10)

Orientation of Ferrite in Pearlite. Robert F. Mehl & Dana W. Smith. *Metals Technology, American Institute Mining & Metallurgical Engineers, Technical Publication* No. 566, Sept. 1934, 12 pages. Previous studies of the formation of pearlite are reviewed. A well-formed dendrite containing 0.75% C was used in determining orientation. The orientation of the original austenite was estimated from the directions of the dendrite spurs. Small discs were cut from the dendrite in such a manner that their faces would be parallel to a cube face of the original austenite. Orientations of the ferrite in the discs were then determined by an X-ray method and the results plotted as pole figures. Preferred orientation was found that could be accounted for by 2 ideal orientation relationships between austenite and ferrite. In the more probable relationship a $\{112\}$ plane in ferrite is parallel to a $\{110\}$ plane in austenite and a $[110]$ direction in this $\{112\}$ plane in ferrite lies parallel to a $[112]$ direction in this $\{110\}$ plane in austenite. The orientation relationships are different from those between martensite and austenite and suggest that the mechanism of formation of pearlite is different from that of martensite. 31 references. JLG (10)

The Crystal Structure of a Complex Copper-Silicon Compound. F. Rolf Morral & A. Westgren. *Arkiv für Kemi, Mineralogi och Geologi,* Vol. 11B, No. 37, Apr. 25, 1934, 6 pages. In English. The usefulness of X-ray methods in complicated cases where a formula can be hardly established by means of ordinary chemical analysis is pointed out. Determining the atomic grouping in the cubic Cr carbide, Westgren recently found that the composition does not correspond to Cr_4C but to $Cr_{23}C_6$. A new case, the structure of a Cu-Si phase of the formula $Cu_{15}Si_4$ is discussed in full. This phase was previously found to exist below 600° C., to be body-centered cubic ($a = 9.694$ A.U.) and homogeneous at 21 at. % Si and to contain 76 atoms/unit cell. EF (10)

The Crystal Structure of Tl_7Sb_2. F. Rolf Morral & A. Westgren. *Svensk Kemisk Tidskrift,* Vol. 46, July 1934, pages 153-156. In English. The points occupied by the atoms of Tl_7Sb_2 are very nearly arranged in a body-centered cubic lattice of the α-Fe type. A number of faint lines indicate that the edge of the unit cell is 3 times that of the small body-centered cube. The length of the parameter was determined to 11.59 A.U. and the density of an alloy with 14.7% Sb was found to be 10.67. Consequently there are 54 atoms in the elementary cube. The "ideal structure" previously determined by Ewald & Hermann disagrees with the intensity of the X-ray interferences. The parameter values have been changed. The distance from an Sb atom to the nearest 4 Tl atoms is 3.10 A.U. The other surrounding Tl atoms are estimated at a distance of 3.38 A.U. and 4 at a distance of 3.48 A.U. EF (10)

Alloys of Iron and Manganese—Part XIII. The Constitution of the Binary Alloys of Iron and Manganese. F. M. Walters, Jr. & Cyril Wells. *American Society for Metals Preprint* No. 2, 1934, 20 pages. Previous observations on low-Mn alloys are summarized and their bearing upon the constitution of the alloys discussed. High-Mn alloys have been studied by microscropic and X-ray methods after heat treatment and from these data, an equilibrium diagram is proposed for the Fe-Mn system. 14 references. WLC (10)

The Metastability of Cementite. H. A. Schwartz. *American Society for Metals Preprint* No. 27, 1934, 26 pages. Hypereutectic Fe-C alloy was prepared containing 0.03% Si and probably not over 0.04% other elements and direct observations of the reaction $Fe_3C = 3Fe + C$ were made at series of temperatures from 1165°F. (630°C.) to above the eutectic melting point with particular attention to range between 1830°F. (1000°C.) and melting point. At all temperatures the reaction was observed to proceed to the right and never to the left. These results contradict thermodynamic deductions of Yap, Chu-Phay, *Transactions, Faraday Society,* Vol. 28, Nov. 1932 and CH_4-H_2 equilibrium of Johansson and von Seth, *Stahl und Eisen,* June 1933, page 633. It is concluded that some of the thermodynamic data accepted by Yap must be in error and more accurate data must be secured. WLC (10)

The Distribution of ThB in Several Metals (Die Verteilung von ThB in einigen Metallen). W. Seith & A. Keil. *Zeitschrift für Metallkunde,* Vol. 26, Mar. 1934, pages 68-69. When an alloy of Pb and ThB is prepared by electrolyzing $PbCl_2$ inoculated with ThB, the distribution of ThB throughout the alloy is uniform as shown by a contact photographic print of the surface; an alloy of Cd and ThB (plus Pb) prepared in the same way showed ThB at the grain boundaries though the amount of ThB and Pb was less than the solid solubility of Pb. Similar results were obtained by melting Cd inoculated with ThB. ThB penetrated Pb along grain boundaries. Thus ThB can only be used to study the diffusion of Pb in Pb and in Tl, but not in Ag, Bi, and Cd. The difficulty seems to lie in a higher solubility of ThB and ThC in the material at the grain boundaries in these metals than in the grain itself. Uncertainties concerning the true solid solubility of Pb and Bi in the metals studied render definite conclusions difficult. RFM (10)

The Determination of Gas in Aluminum by the Hot Extraction Method (Zur Bestimmung von Gas im Aluminium nach dem Heissextraktionsverfahren). K. Steinhäuser. *Zeitschrift für Metallkunde,* Vol. 26, June 1934, pages 136-139. The construction and operation of a new apparatus for the determination of gases in aluminum by vacuum extraction from the molten metal is described. New features include the use of a silicon carbide rod furnace and a magnetic stirring device located outside the furnace, thus obtaining the advantages of induction melting at reduced cost. The use of oxidized aluminum wire on the electromagnets permits operation at moderately high temperatures. Aluminum specimens cleaned prior to analysis with organic solvents gave high results unless they had been subsequently burned off at 300°C. or above. It is concluded that aluminum dissolves little or no CO_2, CH_4 or H_2. 8 references. F[illegible]R (10)

Spontaneous Change of Light-Permeability of Thin Silver foils (Die spontane Lichtdurchlässigkeitsänderung von dünnen Silberfolien). II. A. Jagersberger & F. Schmid. *Zeitschrift für Physik,* Vol. 89, June 26, 1934, pages 557-563. Thin Ag foils which have been produced by cathodic atomization on glass show a spontaneous change of permeability to light which is ascribed to structural changes of the layer, adsorption of gas and to chemical changes.—**III. Relation of Spontaneous Change of Resistance and Structure of Thin Metal foils (Zusammenhang mit der spontanen Widerstandsänderung und der Struktur der dünnen Metallschichten).** A. Jagersberger. *Ibid.* pages 564-581. The relations between permeability to light with the change of electric conductivity is investigated on the basis of the formulas of dispersion valid for metals. Theory and experiment agree very well; a lowest limit of thickness can be established where the electric resistance is infinite and where, consequently, the permeability to light is not changed. Ha (10)

Anomalous Electric Conductivity of Thin Metals (Zur Frage der anomalen elektrischen Leitfähigkeit dünner Metalle). H. Murman. *Zeitschrift für Physik,* Vol. 89, June 16, 1934, pages 426-430. An optical method is described to measure electric conductivity of metallic deposits, without the help of contacts. It was proved conclusively that the conductivity decreases with decreasing thickness of the film (of about 20 Mμ minimum thickness). This is ascribed to the small number of contacts between the groups of molecules in such thin films. Ha (10)

The Change of the Equilibrium Diagram of Fe-Fe_3C-FeS Alloys Due to Addition of Mn. Tomo-o Satô. *Tetsu to Hagane,* Vol. 20, Mar. 25, 1934, pages 155-165. (In Japanese). By thermal and microscropic analyses 110 Fe-Fe_3C-FeS-Mn alloys containing about 0.45%, 0.88% and 1.9% Mn have been studied. Isothermal, projectional and structural diagrams were constructed. As the manganese content increased, the range in which two liquid phases coexist widens in the direction of the low carbon and low sulphur side. The critical point of the monotectic reaction surface in alloy series containing about 1.9% Mn is about 1355°, 7.2% S and 0.53% C, while that in those containing no manganese is 1300°, 8% S and 1.07% C. The experimental result has made clear the mechanism of desulphurization and the decrease of the red shortness in steel due to addition of manganese. As the manganese content increases, the monotectic temperature rises. The sulphide-rich melt separates from a homogeneous melt and comes to the surface, forming slag. It is a well-known fact that in steels containing some manganese, the manganese-rich-sulphide globules exist in the austenite grains, and the red shortness is little. Moreover, as the manganese content increases, the binary sulphide eutectic temperature rises, hence the sulphides separate on grain boundaries of austenite. Therefore, the melting of the boundaries takes place at a higher temperature and the red shortness is decreased. TS (10)

Present Status of the Study of the Nature of Liquid Structures by Means of diffraction of X-Rays (Der gegenwärtige Stand des Studiums der Natur flüssiger Strukturen durch Beugung von Roentgenstrahlen). G. W. Stewart. *Kolloid-Zeitschrift,* Vol. 67, May 1934, pages 130-135. Investigation of diffraction phenomena of X-rays in liquids has given evidence of the existence of a kind of ordered arrangement of molecules which is to all appearance due to molecular forces; this liquid structure seems to be an imperfect imitation of the crystal. Such an ordered group in a liquid is called a "cybotactic" group and consists of mobile molecules. The relation of this conception to previous views on solubility, liquid crystals, and electrolytes is discussed at length. 25 references. Ha (10)

Lattic Patterns (Gitterbilder). K. Strehl. *Zeitschrift für Physik,* Vol. 89, No. 3/4, 1934, pages 254-255. The distinctness of lattice patterns as dependent on wave length and angle of incidence of the illuminating rays is discussed and experimentally investigated. Ha (10)

X-ray Investigations on the Constitution and Decomposition of Martensite. (Röntgenundersökningar över martensitens byggnad och sönderfall). Gunnar Hägg. *Jernkontorets Annaler,* Vol. 118, Apr. 1934, pages 173-197. X-ray investigations combined with density measurements indicates that C atoms are situated between the Fe atoms of a body-centered-tetragonal Fe lattice. Annealing causes a decrease in C content, and in both the axial ratio and unit dimensions. Cubic martensite does not seem to exist, but may consist of tetragonal martensite of low C-content, where the tetragonal symmetry is difficult to observe. Studies on the loss of the C-content during annealing indicate that the rate is proportional to the original C. Even at room temperature the rate is observable with unannealed, but not with annealed steel. The X-rays gave no information on the state in which carbon is precipitated. By treating Fe with CO at low temperatures, a compound with the probable formula, Fe_2C, has been prepared, but the X-ray interferences of this carbide have not been found in annealed steel specimens. 24 references. HCD (10)

X-Ray Investigations of Fine Structure in Copper (Roentgenographische Feinstruktur-Untersuchungen an Kupfer). F. Lihl. *Zeitschrift für Physik,* Vol. 89, June 26, 1934, pages 537-545. An analogy exists between deformation phenomena of Cu and Fe. The existence of a yield point for Cu is proved by X-ray examination, the width of the lines increasing linearly with the stress in the range of plastic deformation. The examination of a fractured endurance-bending sample showed a maximum of lattice disturbance at the fracture which diminished towards both sides. Ha (10)

Crystal Structure of High-temperature Iodine-Silver α-AgI (Kristallstruktur des Hochtemperatur-Jodsilbers α-AgI). Lester W. Strock. *Zeitschrift für Physikalische Chemie,* Sect. B, Vol. 25, May 1934, pages 441-459. A new structural type was discovered in α-AgI in which I forms a body-centered-cubic lattice ($a_0 \pm 5.034$ A. U.) while Ag is chaotically distributed at over 30 places in the I lattice. The unique structure explains the peculiar physical and electrical properties found in α-AgI. EF (10)

The Cobalt-molybdenum System. W P. Sykes & Howard F. Graff. *American Society for Metals Preprint* No. 28, 1934, 35 pages. Microstructures, X-ray photograms, thermal analysis, and measurements of electric resistance and thermal expansion of Co-Mo system are reported and a tentative constitutional diagram constructed therefrom. It is noted that the hardness developed by aging these alloys is approximately the same as for the Co-W system but it is less resistant to temperature. WLC (10)

The System Iron-copper-antimony (Das System Eisen-Kupfer-Antimon). R. Vogel & W. Dannöhl. *Archiv für das Eisenhüttenwesen,* Vol. 8, Aug. 1934, pages 83-92. The system was studied by thermal analysis and microscopic examination. Two ternary compounds were found, FeCuSb and $FeCu_4Sb_2$, the former existing down to room temperature, the latter decomposing. The equilibria obtaining are illustrated by several plane sections through the solid ternary diagram. SE (10)

PROPERTIES OF METALS & ALLOYS (11)

Plastic Behavior in the Light of Creep and Elastic Recovery Phenomena. M. F. Sayre. *Transactions American Society of Mechanical Engineers,* Vol. 56, July 1934, pages 559-561. Paper presented at annual meeting of the American Society of Mechanical Engineers, Dec. 4-9, 1933. During a load cycle there occur the following events: (1) On application of load, a wave of elastic strain moves through bar with velocity of sound, with a slight rise or fall of temperature. (2) Resulting temperature gradient within bar and between bar and air equalizes itself by conduction, with resulting thermal creep. (3) Slip has meanwhile been occurring—under light loads within individual crystals—causing minute changes in length. (4) Under heavier loads slip zones extend into adjoining crystals. Due to different orientations of slip planes, some fragmentation within crystals, and flow among boundary atoms, also occur. Resulting gradual creep may continue, at a decreasing rate, over hours or days. (5) On removal of loading, elastic changes—(1) and (2) above—reverse themselves. Thermal effects produce a hysteresis loop. Even purely elastic changes are therefore accompanied by energy loss. (6) Following removal of loading a gradual pseudo-elastic recovery occurs, bringing piece back part way to original length. This period may last for many days. (7) Two or three experimenters state that after sufficiently rapid loading and unloading the bar may exhibit an apparent memory of past events—first, creeping slightly longer after being unloaded and then creeping in opposite direction. No clear-cut difference between creep effects occuring below so-called elastic limit and larger plastic yield occurring at higher stresses. Amount of creep and hysteresis seems to be related *(a)* to temperature of metal, rise in temperature increasing creep, and *(b)* to its state of internal stress. Mild heat treatments may greatly decrease hysteresis; overloads beyond elastic limit greatly increase it. Any satisfactory theory of mechanism of plastic flow must explain these facts and account for *(c)* elastic recovery effects, *(d)* time lag in initial creep, and *(e)* presence of continuity in metal even after slippage has extended from one crystal into a second differently oriented crystal. Author suggests several hypotheses to explain these. Discussion (page 561). R. W. Carson. Behavior of cold-worked phosphor bronze in general is explained reasonably by Sayre's hypothesis but tests at less than 15,000 lbs./in.^{2} show elastic recovery rate to be much slower than rate of creep under load, as did an investigation (Better Instrument Springs. R. W. Carson. *Electrical Engineering,* Vol. 53, pages 282-286) of inelastic properties of a series of Cu-base alloys. Same mechanism will account for aging or relief of internal stresses with time, for process of age-hardening, for "season cracking" of hard brass, and other time effects. MFB (11)

Grades of Strength (Die Stufen der Festigkeit). G. Meyersberg. *Die Giesserei,* Vol. 21, July 20, 1934, pages 313-314. Distinction is made betweeen strength as referred to the section of the material itself, strength of the lattice, and strength of the atomic nucleus. Changes in the character of the first according to whether the stress is referred to unit of section or to the nominal stresses are pointed out; the curves become the steeper the more the flow of material is prevented, e.g. by notching. Complete prevention of flow means perfectly brittle fracture occurring at "ultimate strength." The ultimate strength is always below what can be expected from the "lattice strength"; very likely this is due to defective places in crystal structure. Numerical values of lattice strength have not yet been determined with certainty up to the present. Still less is known of the "atomic strength," the strength of the atomic nucleus which is higher still than the lattice strength. The relation of mechanical conditions in the production of a material largely determines its strength as measured by the first of the 3 grades of strength. Ha (11)

Seventeenth Annual Meeting of the Deutsche Gesellschaft für Metallkunde 1934 (Deutsche Gesellschaft für Metallkunde, Göttingen, 7-8, Juli 1934). *Die Metallbörse,* Vol. 24, Aug. 4, 1934, pages 986-987; Aug. 11, 1934, pages 1018-1019; Aug. 18, 1934, pages 1050-1051. The following papers are discussed: (1) R. W. Pohl. Mechanism of electric conductivity. (2) U. Dehlinger. Nature of metallic solid solutions and compounds. (3) W. Biltz. Compression of metals on formation of intermetallic compounds. (4) G. Wassermann. Transformations in eutectoid alloys. (5) O. Werner. Utilization of radio-active alloys in metallurgy. (6) F. Sauerwald. Measurement of viscosity of liquid alkali metals in vacuum. (7) A. v. Zeerleder and R. Irmann. Determination of foundry properties of Al alloys. (8) Fr. Körber. Oxide inclusions in steel. (9) R. Vogel. Sulphur-manganese steels. (10) A. Smekal. Investigations on metallic mechanics by means of model materials. (a) Elastic limit and yield point; (b) Nature of recrystallisation phenomena. (11) O. Feussner. Recent developments in the fields of noble metal alloys. (12) H. Bohner. Undercooling of high-melting intermetallic compounds in Al alloys. (13) E. Buschmann. New testing method for bending-tension tests. (14) D. Raub. Crystallisation of binary alloys with eutectics. (15) A. Eucken. Direct determination of the free pass of electrons in metals. (16) E. Vogt. Magnetism and atomic state in metallic solid solutions. (17) K. L. Meissner. Elongations in the case of long measuring lengths. (18) O. Heussler. Ferro-magnetic Mn-Sn-Cu alloys. The original papers must be consulted for the wealth of information. EF (11)

The Nature of Metallic Cohesion (Ueber die Natur der metallischen Bindung). Hans Bomke. *Zeitschrift für Physik,* Vol. 91, Oct. 5, 1934, pages 400-409. A critical review of the different properties of the metallic state leads to the conclusion that the cohesive forces both in the solid and in the liquid state are of purely electrostatic nature and due to the interaction between the metal ions. The distance of the atoms or the ions respectively in the metal lattice is proportional to the cubic root of the atomic volume. The derivation of this ratio by the theories of Sommerfeld and Fermi is explained. Ha (11)

Non-Ferrous (11a)

A. J PHILLIPS, SECTION EDITOR

Practical Method for Determining Heat Conductivity of Small Metal Bars (Methode Pratique sur la Determination de la Conductibilite Thermique des Petits Barreaux Metalliques). P. Vernotte. *Science et Industrie,* Vol. 17, Feb. 1933, pages 77-79. See *Metals & Alloys,* Vol. 5, July 1934, page MA 354. FR (11a)

Non-ferrous Metallurgical Developments During the Past Five Years. Sam Tour. *Metals & Alloys,* Vol. 5, Oct. 1934, pages 213-216. Developments in Al alloys, Cu and Cu alloys, Pb, Mg, Ni and Zn and their alloys are described and some of the new properties uncovered are discussed as conductivity of O_2 free Cu, development of desirable properties in Cu-Be and Cu-Si alloys. Development of greatly improved properties in Zn die castings by use of very pure Zn is described. WLC (11a)

The Nickel-Silvers (Les Maillechorts). G. Duberget. *Revue de Fondérie Moderne,* Vol. 28, July 10, 1934, pages 193-194. This French name (derived from the names of 2 Lyonese French workmen Maillet and Chorier) who applied them first, comprises the ternary Cu-Ni-Zn alloys of which 2 types are used in industry: 1. Those alloys which can usually be rolled hot and made up of α and β solid solutions; 2. Those alloys which can be rolled cold, are composed of only the α solid solution, and with a Ni content of at least 5-6% which however can go up to 30%. This group has a solidification range of 60-90° C., the solidification starts at temperatures from 1100°-1200° which is higher than for the ordinary brasses and bronzes; overheating should be avoided. Melting should go on in an oxidizing rather than in a reducing atmosphere but must be quick and the bath should be kept in contact with the furnace atmosphere as little as possible to avoid carburization. The best way of melting is in induction furnace, but a crucible furnace gives good results provided that a coke with little S is used and that overheating is avoided; a convenient size is charges of 80 to 100 kg. but as this alloy is a bad heat-conductor a charge of 40 kg. is better. Oil as fuel is dangerous due to its atmosphere and difficulty of control. Clay crucibles are preferable to graphite. A cover of borax or powdered glass and lime must be provided on the melt. Cupromanganese, cupromagnesium, or copper phosphide is used for deoxidation. Pouring temperatures should be the higher the higher the content of Ni, e.g.

Ni content, %	10	15	20
Pouring temperature, °C.	1175	1235	1285

Molds should be baked to eliminate porosity. Die-casting is possible but only with certain modifications in composition which at present are kept secret by producers. Ha (11a)

New Alloys of Non-Ferrous Metals (Nieuve legeeringen van niet- ijzer metalen). W. H. D. de Jongh. *Polytechnisch Weekblad,* Vol. 28, Jan. 4, 1934, page 5. Among the corrosion resistant noble metal alloys, prominent mention is made of an Au-Cr (6% Cr) alloy which is rendered more corrosion resistant by additions of 15% Sb. Mg increases the machinability of this alloy and Si the foundry properties. Besides Cr, similar alloying elements such as Mn, Ni, Co, Fe may be added up to 10%. Al alloys containing 1-6% Mg and .05-1% Ti are found to be highly resistant towards sea water corrosion. The considerable corrosion resistance of Mg alloys with .5-2.5% Mn is partly lost during hot working. Quenching from above 400° C. restores the original properties. It has been found that superheating by about 200° C. above the melting point materially improves the physical properties of Al-bearing Mg alloys. If for instance a Mg alloy containing 3% Al is heated 140° C. above its melting point of 630° C. and finally poured at 750° C., a tensile strength of 16.5 kg./mm.^{2} is obtained. The tensile strength is raised to 18.5 kg./mm.^{2} by raising the temperature of the melt to 900° C. for 15 min. Pouring temperature = 750° C. Elongation, yield point, and elastic limit are improved at the same time. Age hardening ability of bronzes is attained by additions of .15% Si and .6% Co. The Si-Co bearing bronze is quenched from 900°-950° C. and aged at 520°-530° C. An age hardening alloy suited for propeller material shows the following analysis: 90.5% Cu, 9% Al, 0.1% Si and 0.4% Co. WH (11a)

Vapor Pressure Measurements on Metals with High Boiling Points (Dampfdruckmessungen an hochsiedenden Metallen). Emil Baur & Roland Brunner. *Helvetia Chimica Acta,* Vol. 27, Oct. 1, 1934, pages 958-969. Discusses critically methods of determining boiling points of metals according to Greenwood and von Wartenberg and applies the latter's method for determining the vapor pressure of 12 metals in atmosphere of N_2, H_2 and A. The results, which are compared with those of former investigators on the same metals, are tabulated and graphically presented. EF (11a)

Zinc and its Alloys. Comprehensive Presentation of Properties (Zink und seine Legierungen. Zusammenfassende Darstellung der Eigenschaften). Arthur Burkhardt. *Metallwirtschaft,* Vol. 13, June 1, 1934, pages 387-395, June 29, 461-468, July 13, 495-500, Aug. 17, 576-580, Aug. 31, 607-612, and Sept. 7, 625-627. A brief survey of the entire field of the properties of Zn and its important alloys with 386 references to the literature. Under pure Zn the atomic, crystallographic, mechanical, thermal, electrical, magnetic and optical properties, gas solubility, electro-chemical properties, resistance to corrosion, toxicity, melting, casting, working, machining, joining, galvanizing, electro-plating and heat treatment are covered. The effect of impurities and alloy additions on the mechanical and technological properties and constitutional diagrams of binary and ternary alloys are given. Under commercial uses Zn base die castings are treated at length, battery Zn, Zn base bearing metals and solders briefly. The use of Zn in brass is not included. CEM (11a)

Potentials in Electrolytes of Foreign Ions (Über die Potentiale in fremdionigen Elektrolyten). O. Essin & M. Lozmanova. *Zeitschrift für physikalische Chemie,* Abt. A, Vol. 167, Dec. 1933, pages 209-220. Potentials of Au in $CuSO_4$, $Cu(NO_3)_2$ and $AgNO_3$ and the corresponding potentials of $Cu/CuSO_4$, $Ag/AgNO_3$ were determined. The Au potential was found to be a straight line function of the potential of the metal of the electrolyte cation. The occurring potentials are interpreted on the basis of adsorption forces. EF (11a)

Light Metal Alloys for Pistons and their Sliding Properties (Leichtmetalle für Kolbenbau und ihre Gleiteigenschaften). O. Engelmann. *Die Metallbörse,* Vol. 24, Apr. 21, 1934, pages 501-502; Apr. 28, 1934, pages 534-535. The drawback of light metal pistons due to their great thermal expansion coefficient are overcome by the latest designs. The advantages of light metal pistons are pointed out. The interrelations between sliding properties, microstructure, pressure and temperature are discussed. An Al alloy with 13.8% Cu, .72% Fe, .3% Si, .43% Zn, .2% Ni shows good sliding properties. Crystals of $CuAl_2$, $FeAl_3$ and some Si compound are embedded in the soft matrix rich in Al. A transformation between 50° and 55° C. visibly affects the sliding resistance but recrystallization takes place at ordinary temperatures. Increasing the Cu content to 16% yielded good sliding properties at low pressures (30 kg./cm.^{2}) but the resistance increased tremendously at 100 kg./cm.^{2} The hard constituents are greatly increased at the expense of the soft primary Al precipitate. Lowering the Cu content to 8.32% resulted in jamming of the piston alloys since the hard, load carrying constituents have been reduced to too great an extent. The soft crystals are overloaded and suffer plastic deformation resulting in a drastic increase of the sliding resistance. KS245 with 12% Si, 4-5% Cu, 1-2% Mn and "Supra" containing 20% Si, 4-5% Cu, 1-2% Mn (.3-1% Fe) operated well at sliding pressures of 30-50 kg./cm.^{2} At higher pressures temperature rises due to inferior heat conductivity of the Si-rich constituent resulted in plastic deformations. The correlation of microstructure to seizing is discussed with reference to "Alusil" (21-23% Si, 1% Cu max. .3-1% Fe) and KS 280 (21-23% Si, .3-1% Fe, .45% Zn, 1.35% Mg, 1.5% Co, .8% Ni). The former failed at 120 kg./cm.^{2} and the latter at 50 kg./cm.^{2} sliding pressure: Elektron metal containing 18.2% Al, 1.41% Si, bal. Mg. failed at 30 kg./cm.^{2} EF (11a)

Transport of Matter in Solid Substances (Materietransport in festen Körpern). G. v. Hevesy. *Zeitschrift für Elektrochemie,* Vol. 39, July 1933, pages 490-500. The transfer of matter, for instance ions, in a melt is not a very specific phenomenon as the ions can move without great hindrance under the influence of interionic forces. In the solid state, however, the ions and atoms are subject to the forces of the crystal lattice which order them or hinder their mobility so that considerable energy is required to effect a change of place of matter. The phenomenon of diffusion of different metals and the mobility of the ions and atoms is explained particularly for the state at and near the melting point where mostly a discontinuity in the mobility curves takes place. In general, it can be said that the possibility of transfer of matter is an inherent property of the solid substance rich in energy. The accumulation of energy occurring at different places of the crystal leads to a weakening of crystal forces which hinder the mobility of the elements building up the lattice and makes it possible for these elements to change places. Chemically different crystals are influenced very differently according to size, electric charge and polarization of the elements of the lattice structure. Combinations of cations of rare atoms with anions of low electric affinity form systems of good electric conductivity. Metallic systems in which small atoms of rare elements lie side by side with large atoms of base elements show a high diffusion velocity. These ideas are illustrated and exemplified by examples of diffusion of NaCl, Pb—Au and others. 48 references.
Ha (11a)

Utilization of Tantalum in the Chemical Industry (Zur Verwendung des Tantal in der chemischen Industrie). Ralph W. Harbison. *Die Metallbörse,* Vol. 24, Apr. 28, 1934, pages 533-534. Natural occurrences, chemical preparation and refining are summarized. The elimination of gases (H_2) which render Ta brittle is rather difficult due to its high melting point of 2770° C. Vacuum melting in MgO crucibles between W and Ta electrodes is generally applied to secure Ta of 99.5-99.9% purity. Ta is hard but tough and ductile. It can be easily drawn, hammered, rolled and drilled at room temperature. Without intermediary annealing Ta can be rolled down from 7 mm. to .05 mm. Ta should not be heated to above 400° C. in air. However alloys of Ta with Mo, W, C, Mn, Ni, V, Si are exceedingly heat resistant. Physical properties and resistance to chemical reagents are given in tables. Unlike Pt, Ta is resistant against aqua regia but is attacked by HF, HF-HNO_3 mixtures and hot concentrated NaOH. Highly pure Ta is attacked slowly by HF, but impurities cut down radically its corrosion resistance. Ta absorbs 740 times its own volume of H_2. Gas absorption causes brittleness of the metal. Ta can be easily welded to itself and other metals notably Ni. Its price is 1/7 of Au and 1/12-1/13 of Pt. Ta is harder and stronger than Pt. Weight sets made of Ta are cheaper than those of Pt-Ir alloys. The principal drawback of this metal however is its low resistance against HF mixtures and its sensitivity to heating above 400° C. EF (11a)

Alloys of Nickel, Copper and Zinc (Les Alliages de Nickel, de Cuivre et de Zinc). L. Guillet. *Cuivre et Laiton,* Vol. 7, Sept. 1934, pages 425-426. Nickel-silver alloys contain 57-64% Cu, 13-21% Ni, and 15-22% Zn; the most widely used composition is 60% Cu and 20% each of Ni and Zn. The density of a nickelsilver can be calculated from the formula $d = 7.695 + 0.006(3Ni - 2Cu)$; conductivity is 35 microhms/cm.^{3} Mechanical properties depend to a certain extent on Ni content and on cold-working. Tensile strength varies from 24 to 35 kg./mm. for 8-25% Ni. A good corrosion resistance requires at least 10% Ni against humidity and at least 18% Ni against saline solutions. Industrial applications are reviewed. Ha (11a)

Electron and Lattice Conduction in the Heat Flow in Metals (Elektronen- und Gitterleitung beim Wärmefluss in Metallen). E. Grüneisen & H. Reddemann. *Annalen der Physik,* Series 5, Vol. 20, Sept. 1934, pages 843-877. Measuring the heat conductivity of some pure metals and some alloys at low temperatures (—183 to —251° C.) in order to find whether heat is conducted in metals by electrons or by deformation of the lattice structure it could be stated that in pure metals the major part is due to electron conduction; both effects are additive except at lowest temperatures where lattice conduction almost ceases. The disturbing influences of alloying elements were also determined and are discussed. Ha (11a)

The Temperature Variation of the Thermoelectric Properties and the Specific Heat of Nickel-Chromium Alloys. A. W. Foster. *London, Edinburgh, & Dublin Philosophical Magazine & Journal of Science,* Vol. 18, Sept. 1934, pages 470-488. A more accurate method of measuring temperature and thermoelectric power to eliminate errors due to the intrinsic magnetization varying with temperature was developed. Ni wires and wires with 1 and 2% Cr were tested, the 2 alloys showed 55 and 30% drop respectively in spec. heat at the Curie point measured in Ni. 11 references. Ha (11a)

Investigation of the Vapor Pressures of Metals with High Boiling Points. Part 2. Determination by Means of Ruff's Spring Balance Method (Über die Dampfdrucke hochsiedener Metalle. 2. Bestimungen nach der Ruff'schen Federwaagenmethode). Joseph Fischer. *Zeitschrift für anorganische und allgemeine Chemie,* Vol. 219, Sept. 29, 1934, pages 367-375. The Ruff spring balance method is considered to be of special interest, it allows vapor pressure and equilibrium conditions to be measured up to high temperatures. Fischer has perfected the Ruff method, he uses a closed crucible of Zr oxide for the substance and suspends it from a spring balance. Furnace subjected to a linearly increased temperature and course of vaporization continuously observed. Readings of weight at intervals are put on a vaporization curve, an inflection point (boiling point) divides curve into evaporation curve (left side) and boiling curve (right side). Boiling point is easily identified by the linearity of evaporation curve and curved shape of boiling curve or vice versa depending upon the scale used. Plotting log $\frac{G}{z}$ (G = loss in weight, z = time interval) against z, the evaporation curve is linear and boiling curve is exponential, if $\frac{G}{z}$ is plotted against z the linearity is reversed. Integration of the $\frac{G}{z}$ versus z curve gives velocity of evaporation and boiling and is easily carried out due to linearly increased temperature, this gives $G = A_2Z + B_3$ for the amount evaporated, $G = K_6Z^2 - k_7Z + k_8$ for the amount boiled. Vaporization curves for silver are given on page 368 and a boiling point of 1725° C. indicated at inflection. Attempt made to obtain Pt and Cu curves but Pt reduced Zr oxide crucible at 2000° C. and in C crucible Pt carbide formed, Cu boiled too energetically in C crucible. Vapor pressure constants of Ag were calculated and found to be nearer the theoretical values than previously. WB (11a)

Important Metals Other Than Iron. *Metal Progress,* Vol. 26, Oct. 1934, pages 43-47. Increased use of Al and Mg alloys and their applications are discussed. Ni alloys for corrosion resistance, permanent mold brass castings and zinc casting developments are discussed and references to more detailed discussions given. WLC (11a)

Reaction Kinetics Between Alkaline Earth Metals and Nitrogen and Other Gases II. Kinetics of the Reaction Between Alkaline Earth Metals and Nitrogen (Zur Kinetik der Reaktion der Erdalkalimetalle mit Stickstoff und anderen Gasen. II. Die Kinetik der Reaktion der Erdalkalimetalle mit Stickstoff). A. v. Antropoff & K. H. Krüger. *Zeitschrift für physikalische Chemie,* Abt. A, Vol. 167, Dec. 1933, pages 49-53. The reaction velocity of Sr and Ba was investigated in relation to temperature. Sr and Ba are always considerably more reactive towards N than Ca. Even in case of extremely pure metals, no passivity effects could be observed. The reaction progresses through the whole mass of metals under nitride formation. The reactions start at 350° and 200° C. for Sr and Ba respectively. Rising temperatures result in increasing reaction speeds with both metals. Be and Mg are always passive. Sr and Ba always active and Ca active or passive (pure). Li behaves similarly. EF (11a)

Reaction Kinetics Between Alkaline Earth Metals and Nitrogen and Other Gases III. Effect of Na and other Substances as Initiator of the Reaction Between Calcium and Nitrogen (Zur Kinetik der Reaktion der Erdalkalimetalle mit Stickstoff und anderen Gasen. III. Über die Wirkung des Natriums und anderer stoffe als "Erreger" der Reaktion zwischen Kalzium und Stickstoff). A. v. Antropoff & K. H. Krüger. *Zeitschrift für physikalische Chemie,* Abt. A., Vol. 167, Dec. 1933, pages 54-61. Passivity of Ca at 700° C. is not eliminated by Na. Na does not act as a catalyst during the reaction between Ca and N but only as an initiator, i.e. after starting the reaction by a small amount of this metal, the reaction proceeds at a larger speed if Na is removed again otherwise it checks the reaction like an indifferent gas. Sublimation tests *in vacuo* on Ca and Na simultaneously show that Na exerts an activating effect. EF (11a)

Reaction Kinetics Between Alkaline Earth Metals and Nitrogen and Other Gases IV. Kinetics of the Reaction Between Calcium and Nitrogen in the Presence of Argon (Zur Kinetic der Reaktion der Erdalkalimetalle mit Stickstoff und anderen Gasen. IV. Die Kinetik der Reaktion zwischen Calcium und Stickstoff in der Gegenwart von Argon). A. von Antropoff & H. Klingebiel. *Zeitschrift für physikalische Chemie,* Abt. A, Vol. 167, Dec. 1933, pages 62-70. Hot metallic Ca chips are used to remove N from Ar. The reaction stops if the N content drops to 1%. He and Ne can be purified more completely.
EF (11a)

Influence of Ce in Al Alloys (Influenzo di Ce nelle leghe di Al). M. Bosshard. *Alluminio,* Vol. 3, May-June 1934, pages 205-209. Addition of Ce to Al or Al-Mg alloys has no appreciable influence on their electrical, chemical, or mechanical properties, but does have a deleterious effect on Aldrey and Avional. Aldrey containing Ce has lower tensile strength, while the resistance to corrosion is unchanged, and the electrical conductivity increases slightly. Small additions of Ce to Avional lowers its tensile strength markedly, and also decreases its resistance to corrosion. AWC (11a)

Aluminium and Special Alloys (L'Aluminium et les Alliages Spéciaux). Bocahut. *Revue de Fonderie Moderne,* Vol. 28, July 25, 1934, pages 205-211. Melting, pouring and casting practice is discussed in particular and the means to obtain a sound, dense casting. The most applied alloys for foundry purposes are: 1. Alloys with Zn (German alloy of 10% Zn, 3% Cu) possess good pourability but are brittle when hot and can stand only small stresses in machining. 2. Alloys with Cu have good pourability and better strength, also at higher temperatures (American alloy with 8% Cu offers a particularly good resistance to impact). 3. Si alloys have good pourability, low spec. density, are brittle when hot, but have good mechanical strength and corrosion resistance. 4. Hypersilicic alloys, containing 18 to 27% Si have a minimum expansion, and a density of only 2.45-2.5; they are very hard and difficult to machine. They are used for pistons. 5. Al alloy with 7% Cu, 2.5% Si has good mechanical properties up to 100° C. and can be heat-treated; it resists well repeated impacts. 6. The various alloys of the duralumin type are difficult casting; usual composition: Al 92.5%, Cu 4%, Ni 2%, Mg 1.5%, Si 0.7-2% according to the type of casting. Density is 2.80, shrinkage 13%. Special method of obtaining proper composition in melting the various components is described. Mechanical properties and compositions of other complex alloys are given; and fields of applications enumerated. Ha (11a)

Correlation Between Conductivity under Light Exclusion and Temperature of Selenium (Über die Abhängigkeit der Dunkelleitfähigkeit des Selens von der Temperatur). P. Scharawsky. *Physikalische Zeitschrift der Sowjetunion,* Vol. 5, 1934, No. 3, pages 511-514. Contradictory results of previous investigations on the resistance changes in metallic Se at various temperatures is ascribed to the interfering effect of light. With complete exclusion of light the conductivity of Se over the temperature range of —183° - +60° C. was found experimentally to follow the vant'Hoff equation $\sigma = A\ e^{-B/T}$ whereby $B \backsim 0.1$ volts. EF (11a)

New Investigations on the Diffusion of Hydrogen Through Palladium (Nouvelles recherches sur la diffusion de l'hydrogène à travers le palladium). Victor Lombard & Charles Eichner. *Bulletins de la société chimique de France,* Vol. 4, Nov. 1934, pages 1176-1206. **(Neue Untersuchungen über die Diffusion von Wasserstoff durch Palladium).** Peters. *Brennstoff Chemie,* Vol. 15, Apr. 1, 1934, page 134. Permeability of Pd sheets of .1-1 mm. thickness to H_2 in relation to pressure, temperature and impurities in the metal is studied. The diffusion-temperature relationship checks Richardson's theoretical derivations (*Philosophical Magazine,* Vol. 7, 1904, page 276, Vol. 8, page 1). The diffusion of H_2 in Pd is strongly affected by impurities in the latter. See also *Metals & Alloys,* Vol. 5, Sept. 1934, page MA 457. EF (11a)

Vacuum Melted Beryllium Alloys (Vakuumgeschmolzene Beryllium-legierungen). W. Hessenbruch. *Zeitschrift für Instrumentenkunde*, Vol. 54, Aug. 1934, pages 286-288. See *Metals & Alloys,* Vol. 5, Sept. 1934, page MA 456.
EF (11a)

The Exact Measurement of the Specific Heats of Metals at High Temperatures. V. Specific Heats and Thermal Hysteresis of Beryllium. F. M. Jaeger & E. Rosenblom. *Recueil des Travaux Chimiques des Pays-Bas,* Vol. 53, Apr. 15, 1934, pages 451-463. In English. Crystalline metallic Be heated above 500° C. undergoes a reversible change of its internal condition. The metal returns only very slowly to its original condition. The X-ray spectrum of Be heated above 635° C. exhibits a number of additional lines, which—as the lines of the untreated metal—correspond to a hexagonal arrangement. The relative intensities of the new lines increase with rising temperatures and do not disappear even at —80° C. The physical properties of Be are strongly dependent on its preliminary thermal treatment and the time elapsed since its cooling down from elevated temperatures. Presence of minute quantities of Be oxide (for instance due to grinding) almost completely prevents the internal transformations. The phenomena are ascribed to a mobile, more or less dynamical equilibrium and the formerly suggested interpretation, i.e. the presence of 2 individual α and β modifications of Be is withdrawn. X-ray spectra do not indicate the presence of a solid solution of varying composition. A critical discussion—partly in conjunction with Smith—on the possibilities of (1) a mobile, internal equilibrium of 2 pseudo-components, say δ and ϵ Be (2) that in the solid phase the 2 pseudo-components from a dimorphous series of mixed crystals showing a hiatus, (3) that the occurrence of the β-spectrum is a phenomenon quite apart from the retardation phenomena.
EF (11a)

Manganese Copper (Über Mangankupfer). E. R. Thews. *Die Metallbörse,* Vol. 24, Apr. 14, 1934, pages 470-471; Apr. 21, 1934, pages 502-503. Mn-Cu alloys are widely used as deoxidizers. The electric furnace eliminated the former production difficulties. The older production methods are reviewed. The effect of increasing Mn additions on Cu is:

Cu	Mn	tensile strength kg./mm.²	elongation %
100	—	19.6	49
99	1	22.3	41
95	5	26.5	43
92.5	7.5	28.4	30
84	16	34.7	28
79	21	40.2	12
74	26	42.1	12
68	32	27.7	3

The physical properties of Cu-Mn alloys are not superior to the cheaper Cu-Zn alloys. However they remain practically unchanged up to 200°-250° C. Tables present data on 2 Cu-Mn alloys with 6% and 12% Mn between room temperature and 400° C. Stay bolts of a Cu-Mn alloy (4% Mn) lasted 58 times as long as pure Cu. Cu-Mn alloys act quite similar to Cu-P alloys as deoxidizers. A rather fluid slag of low specific weight is formed. A Cu-Mn alloy with only 4-6% Mn is usually employed and small amounts of Al and Si increase the deoxidizing effect. The author prefers Mn-P-Cu alloys as deoxidizers. EF (11a)

Thermo-Chemical Measurements on the Oxides of Copper, Rhodium, Palladium and Iridium (Thermo-chemische Messungen an den Oxyden des Kupfers, Rhodiums, Palladiums und Iridiums). Lothar Wöhler & N. Jochum. *Zeitschrift für physikalische Chemie,* Abt. A, Vol. 167, Dec. 1933, pages 169-179. Evaluation of dissociation heat values of CuO based on experimentally determined O pressures yielded data which were not in agreement with the generally accepted formation heat of CuO. The formation heats of both Cu oxides were redetermined by 2 different ways. These methods were also checked on Rh, Pd, and Ir. EF (11a)

Special Alpax (Les Alpax Spéciaux). P. Barrand. *Revue de l'Aluminium,* No. 61, May 1934, pages 2421-2423. The addition of 0.3 to 0.5% Mn and 0.2 to 0.3% Mg improves the mechanical properties of Alpax when properly heat treated. Details of best treatments and results are tabulated. AH (11a)

Heats of Combustion of Some Metals and Metal Nitrides (Die Verbrennungswärmen einiger Metalle und Metallnitride). B. Neumann, C. Kroeger & H. Kunz. *Zeitschrift für anorganische und allgemeine Chemie,* Vol. 218, July 14, 1934, pages 379-401. Method of calorimetric determination of heat of combustion and calculation therefrom of heat of formation of nitrides are described. The following values were determined:

Metal	Heat of combustion	Nitride	Heat of formation
Zr	258.2 ± 0.3 kcal.	ZrN	82.2 kcal.
Ti	225.3 ± 0.3	TiN	80.3
Mo	180.4 ± 0.06	MoN	16.6 ± 0.6
Be	$145.3_3 \pm 0.18$	Be_3N_2	135.3
Ta	499.9	TaN	58.1
Th_3N_4	564.7_6 (for the nitride)	Th_3N_4	78.1

The relation of heat of formation of nitrides to the order number of the elements is discussed and curves are developed which permit interpolating values for the formation of nitrides of Sc, V, Y, Nb and W. 51 references. Ha (11a)

Comparison between the Precipitation Hardening of a Worked and a Cast Alloy (Vergleich der Aushärtung einer gekneteten und einer gegossenen Legierung). P. Wiest & U. Dehlinger. *Zeitschrift für Metallkunde,* Vol. 26, July 1934, pages 150-152. Considering the cause of the lower and more slowly attained precipitation hardening of cast as compared with worked 5% Ag-Cu alloys it is concluded that dissolved gases play no part, while relative homogeneity and the size of the mosaic blocks are important. The Brinell hardness of cast polycrystalline and single crystal alloys quenched after 85 hours at 750° C. was measured periodically during aging at 350° C. The hardness maximum is reached at about the same time in both polycrystalline and single crystal cast metal but the latter attains greater hardness, probably because of its greater homogeneity. The recrystallized wrought alloy reaches its maximum hardness more rapidly, attaining about the same degree of hardness as the cast single crystal. The time required for the cast alloy to age to maximum hardness decreases progressively with increased amounts of previous working. FNR (11a)

Recent Progress of Die-Casting Methods of Brass (Les récents Progrès des Procédés de Coulée sous Pression du Laiton). W. Sieg. *Revue de Fonderie moderne,* Vol. 28, Sept. 25, 1934, pages 271-273. Methods and machinery used in America are described, composition of alloys used and physical properties of diecastings of Cu-base alloys are given. Ha (11a)

Iridium, Osmium and Ruthenium. F. Carter. *Metal Industry,* London, Vol. 42, June 2, 1933, page 570. The greatest use of Ir, Os and Ru is as hardeners for Pt and Pd; the latter is mainly alloyed with Ru and used as contact material in magnetos. The melting points of Ir as recently determined exactly is 4447° F. and that of Os 4890° F., highest of any metal. Although the melting point of W is still higher it does not actually melt, the W particles sinter together. Ha (11a)

Production of High Melting Point Metals by Thermal Dissociation of their Compounds (Die Herstellung von hochschmelzenden Metallen durch thermische Dissoziation ihrer Verbindungen). A. E. van Arkel. *Metallwirtschaft,* Vol. 13, July 20, 1934, pages 511-514. Metals, such as Zr, Ti, Hf and Th, produced by the method previously described by the author (*Metallwirtschaft,* Vol. 13, June 8, 1934, pages 405-408) are more ductile than those made by melting, because they are free from impurities, especially O. As soon as these metals are exposed to air a thin oxide layer forms on them. Zr and Ti prepared by the iodide process can be rolled into rods and sheets. W is deposited in fairly large crystals, each of which is ductile, but their cohesion is very poor. By forming a W wire slowly it can be made from a single crystal, which is then ductile. Other metals, such as Mo and Zr, can be deposited on a W single crystal and they continue to form the same single crystal. Ductile V and Cr have also been obtained, but B and Si are always brittle and should not be considered metals. When B and Si are made, they are deposited on W wires. B diffuses into the W during the process. TiN and ZrN can be obtained by heating a wire in a mixture of H, N, and $TiCl_4$ or $ZrCl_4$. The nitrides have the same crystal structure as NaCl and are very brittle, but their electric resistance is smaller than that of the corresponding metals. CEM (11a)

Copper and Oxygen. L. L. Wyman. *General Electric Review,* Vol. 37, Mar. 1934, pages 120-129. Refining of Cu is discussed to show how O_2 is present in commercial Cu. Since high O_2 content often imparts low ductility; O_2 variations in a section may cause difficulties. Reducing gases at elevated temperatures have disastrous effects on O_2 bearing Cu, causing "blowing" and embrittlement. Numerous photomicrographs and typical failures are discussed along with deoxidizing treatments. CBJ (11a)

X-Ray-Optical Tests with Thin Nickel Films (Roentgenoptische Untersuchungen an dünnen Nickelschichten). R. Riedmiller. *Annalen der Physik,* Series 5, Vol. 20, July 1934, pages 377-403. Thin Ni films of 400-1750 A.U. were produced by evaporation in a high vacuum and density, refractive index for X-rays and spec. electric resistance determined. Densities of such thin films were about 20-25% less than normal. The spec. resistance was measured for thicknesses from about 200 to 2000 A.U.; the final value was about 8.8×10^{-4} ohm/cm. while the normal value for Ni is 7×10^{-6} ohm/cm. The refractive index was generally higher than expected by the dispersion theory. 18 references. Ha (11a)

The Diffusion of Zinc and Iron at Temperatures below the Melting Point of Zinc. Gilbert Rigg. *Metal Industry,* London, Vol. 44, Mar. 16, 1934, pages 301-302. See *Metals & Alloys,* Vol. 5, July 1934, page MA 354. Ha (11a)

Magnesium-Chromium as a Deoxidizer of Copper. Charles Vickers. *Metallurgia,* Vol. 10, June 1934, page 43. Favorable results were obtained by adding both Cu-Mg and Cu-Cr alloys to casting Cu. Electric conductivities as high as 78% were obtained. JLG (11a)

A New Light Alloy. *Engineer,* Vol. 158, July 20, 1934, pages 70-71; *Gas & Oil Power,* Vol. 29, Aug. 1934, page 222. Brief notice of alloy developed and patented by J. Stone and Co., Deptford, England, under the name of Ceralumin "C." It contains Cu 2.5%, Ni 1.5%, Mg 0.8%, Fe 1.2%, Si 1.2%, Ce 0.15%. Al, remainder. If artificial aging is replaced by aging at room temperature for five days, a modified form of the alloy is produced called Ceralumin "D". LFM + WH (11a)

Magnesium Alloy Parts, Why Used and How Designed. *Product Engineering,* Vol. 5, Aug. 1934, pages 300-302. Magnesium alloys in engine parts are said to give not only reduction in dead weight, but also less inertia, lower bearing pressures, easier rotating balance and reduced centrifugal forces, besides corrosion protection. Mg alloys can also replace wood in instruments. Ha (11a)

The White Alloys of Tin. IV. Britannia Metal. *Tin,* June 1934, pages 8-9. Composition of this metal varies greatly and is often very similar to pewter. English Britannia contains 95.23% Sn, 3.4% Sb, and 1.36% Cu. The presence of the 2 latter elements makes it harder than pewter. It should be poured at between 315°-330° C. and cast directly into molds preheated to within 50° of the casting temperature of the alloy; the molds should be coated with lamp black. Presence of Zn is definitely injurious to Britannia metal. Several other compositions of Sn with Pb, Sb, Cu or Zn are used and described. Ha (11a)

Some Properties of Cupro-nickel Containing Beryllium (Sur quelques proprietes d'un cupro-nickel au glucinium). Marcel Ballay. *Comptes Rendus,* Vol. 198, Feb. 5, 1934, pages 578, 580. See "Cupro-Nickels with Beryllium," *Metals & Alloys,* Vol. 5, July 1934, page MA 355. OWE (11a)

Thermal Analysis of the System Rubidium-Mercury. Review of the Mercurides of the Alkali Metals (Thermische Analyse des Systems Rubidium-Quecksilber. Uebersicht über die Merkuride der Alkalimetalle). W. Biltz, F. Weibke & H. Eggers. *Zeitschrift für anorganische und allgemeine Chemie,* Vol. 219, Aug. 14, pages 119-128. The complete constitutional diagram of the system Rb-Hg was developed; 2 compounds characterized by melting point maxima exist: $RbHg_2$ Rb_2Hg_7. Other compounds with not so pronounced melting temperatures are Rb_3Hg_4, Rb_5Hg_{18}, Rb_2Hg_9, $RbHg_6$ and $RbHg_9$. The system is very similar to the systems Li-Hg, Na-Hg, K-Hg and Cs-Hg; the capacity of the alkali metals to combine with Hg increases in the series from Li to Cs. Ha (11a)

The Properties of Ultra-Light Magnesium Structural Alloys Compared with Other Engineering Metals (Magnesium Alloys Used in the Construction of Aircraft, Railroad Cars, Automobiles and Trucks). A. E. Drucker. *State College of Washington, School of Mines & Geology, Mines Information Bureau, Information Circular* No. 5, Apr. 1934, 14 pages; *Metallurgical Research Bureau, Information Circular* No. 6, June 1934, 6 pages. A compilation. AHE (11a)

Electrometallurgical Research and Its Relation to the Grand Coulee Power Development. (Some Facts on the Ultra-light Structural Alloys of Magnesium and Aluminum.) A. E. Drucker. *State College of Washington, School of Mines and Geology, Metallurgical Research Bureau, Information Circular* No. 8, July 9, 1934, 6 pages. A brief discussion of the structural alloys of Mg and Al. AHE (11a)

Malleability of Nickel and of Monel Metal. Owen W. Ellis. *Iron Age,* Vol. 133, May 10, 1934, page 30. See *Metals & Alloys,* Vol. 5, July 1934, page MA 355. VSP (11a)

Properties of Lead and Lead Alloy Cable Sheaths. J. C. Chaston. *Electrical Communication,* Vol. 13, July 1934, pages 31-50. The demands on the sheath material vary with different types of cable. Telephone cables in ducts require a ductile sheath, power cables in ducts and aerial telephone cables a hard, fatigue-resisting sheath, while armoured cables in trenches make the least severe calls of all. Reviewing the literature, it is pointed out that age-hardening has usually been overlooked and that experimental correlation between the behaviour of extruded cable sheath and conventional test specimens machined from rod is lacking. Tests were made on unflattened sheath samples extruded in a factory cable press from unalloyed Pb, the Sb alloys with 0.66, 0.8, and 1.0% Sb, and the British Non Ferrous ternary alloys No. 1 (0.5% Sb, 0.25% Cd) and No. 3 (0.4% Sn, 0.15% Cd). Age-hardening occurred in the No. 1 ternary and all the Sb alloy sheaths. Hardness tests on samples cooled at different rates showed the aging of the Sb alloys to be less affected by rate of cooling than that of the No. 1 alloy. Fatigue tests were made with a rotating beam machine using sheath samples as long as 22 inches to ensure a central fracture. The endurance of the lead sheath, which did not age-harden, agreed well with published results on rod, and abrading the surface with emery cloth had little effect. The endurance of the alloy samples was determined at their maximum hardness. Tensile, creep, bursting, and corrosion tests on sheath samples are described. 48 references. JCC (11a)

Elongation Values of Copper and Copper-rich Alloys. Maurice Cook & Eustace C. Larke. *Journal Institute of Metals,* Vol. 55, 1934 (Advance Copy), 20 pages. Tensile tests were made on strips of 70:30 and 64:36 brass, high-conductivity Cu, 80:20 Cu-Ni, and gilding metal. Marks 0.125″ apart on each specimen enabled the determination of elongation values over different lengths. With a gage length of 1″, varying the parallel portion from 1.5 to 8.5″ had no influence on elongation over 1″. When the thickness of the metal varied from 0.125″ to 0.020″ elongation values on a 2″ gage length and 0.5″ parallel portion did not seem to be affected, but with metal thinner than 0.02″ elongation decreased rapidly with decreased thickness. When the width was varied from 0.25″ to 1.5″ with specimens 0.06″ thick elongation decreased with decreasing width. Varying the rates of strain from 0.06″ to 0.55″/in. gage length/min. did not affect elongation values. A detailed study of effect of gage length on elongation values of 70:30 brass subjected to different degrees of cold working was made. Values of total and uniform elongation were determined. Formulae for obtaining uniform elongation are reviewed. 15 references. JLG (11a)

Ferrous (11b)

E. S. DAVENPORT, SECTION EDITOR

Difference Between Iron, Steel and Cast Iron (La distinction entre le fer, l'acier et la fonte). A. PORTEVIN. *Génie Civil,* Apr. 1934, page 384. The present advances in metallurgical practice render the definition of these alloys, as proposed by Howe in 1912, obsolete. Independent of manufacturing methods, a sharp distinction can be obtained by classifying as cast iron, iron carbon alloys containing eutectic, as steel those containing eutectoid and as iron the alloys containing no eutectoid and, therefore, free from pearlite. JDG (11b)

Investigation of Rails Made of Khalilov Steel (Containing Chromium and Nickel). K. F. STARODOUBOV & P. V. ZIMBAL. *Domez,* No. 8, 1934, pages 3-14. In Russian. Five ingots made in 3 plants using different methods were rolled into rails and compared with plain C rails made by open hearth and Bessemer process, both as rolled and heat treated. Experimental rails contained 0.47-0.52% C, 0.13-0.27% Cr and 0.50-0.79% Cr. Elastic limit of hot rolled alloy rails was better than the elastic limit of both hot rolled and heat treated open hearth rails and was equal to that of hot rolled Bessemer rails. Tensile strength of the heat treated alloy rails was equal to that of heat treated open hearth rails and superior to all others. Other properties varied similarly. (11b)

Elastic Limit of Structural Steels of 50 and 60 kg./mm.^{2} (Limite élastique des Aciers de Construction à 50 et 60 kg./mm.^{2}). J. LACHASSAGNE. *Usine,* Vol. 43, July 5, 1934, pages 35-37. Permanent deformations occurring at stresses close to the elastic limit were studied. The stress-elongation curves of steels of 50 and 60 kg./mm.^{2} are straight lines up to the point where the first permanent deformation appears; if the latter is small, (less than 0.01%) the curve of stress vs. purely elastic elongation is still a straight line; the purely elastic elongation is obtained by difference after return to zero stress. The time factor, i.e. duration of stress, is of no great importance; the deviation between loads producing an elongation of 0.1% whether applied 5 min. or 10 sec. was less than 1 kg./mm.^{2} For practical purposes the elastic limit at 0.1% set after holding in tension for 5 min. defines the elastic limit of a metal. If the speed with which the tension is applied is less than 0.5 kg./mm.^{2}/sec. the error due to too rapid loading is reduced by 0-3 kg. Ha (11b)

The Influence of Preliminary Treatment and Rerolling on the Properties of Cold-Strip Steel (Ueber den Einfluss der Vorbehandlung und des Nachwalzens auf die Eigenschaften von kaltgewalztem Bandstahl). H. LASSEK. *Mitteilungen aus dem Forschungs-Institut der Vereinigten Stahlwerke Aktiengesellschaft, Dortmund,* Vol. 4, Apr. 1934, pages 23-37. Cold-rolled strip steel is usually rerolled after the last annealing in order to obtain the desired hardness. The degree of preliminary deformation in rolling effects vary considerably the properties obtained after rerolling. The critical range of deformation must always be avoided on account of the subsequent growth of coarse grains. The effect of treatment before annealing is most pronounced for small amounts of rerolling and disappears with higher reductions; this is of importance for deep-drawing steels. Aging increases brittleness more in lightly rerolled strips; strips rerolled to a greater degree age less. 19 references. Ha (11b)

Soft Cast Iron. L. W. BOLTON. *Bulletin of the British Cast Iron Research Association,* Vol. 4, July 1934, pages 6-10. Discussion of best means of obtaining castings which are as soft and machinable as possible in the as-cast condition and heat-treatment to impart maximum machinability and softness. Soft castings should not contain more than 0.5% P, except in very light castings; total C as high as possible, but coarse flakes should be avoided. The most suitable Si content depends on section of casting, but should not exceed 3% as above this it exerts a hardening effect. S and Mn should be in balance, free Mn is, however, preferable to free S. In annealing castings to increase machinability the aim should be to break down, as completely as possible, any combined C; 800° C. usually suffices for castings with 2% Si. The critical temperature is raised about 30° C. for each 1% Si. Cooling down to about 500° C. should occupy at least one hr. Annealing for stress relief is done best by slowly heating to 400° C., maintaining this temperature 6-8 hrs. followed by cooling in the furnace. This temperature should not be greatly exceeded if carbide breakdown is to be avoided. No loss of strength results from this treatment; rather a slight increase is found due to release of internal stresses. Ha (11b)

Effect of Silicon on a Chilled Roll. KOHEI TANIGUCHI. *Seitetsu Kenkyu (Metallurgy Reports from the Yawata Iron Works, The Nippon Seitetsu Co. Ltd., Japan),* No. 131, June 10, 1933, pages 1-8. Pig iron (3.11 C, 0.58 Si, 0.57 Mn, 0.53 P, 0.038 S) to be used for a chilled roll was heated to 1500° C. and cast in a mold at 1280° C. The structure of the chilled part of the specimen thus prepared was similar to that of a chilled roll. Various amounts of Si up to 7.28% were added to the pig iron and 12 kinds of alloys were cast in manner mentioned above. C contents of these alloys decreased with increase of Si. As the Si content was increased up to 1.7%, the Shore hardness of the chilled part increased gradually, while both the depth of the chill and the mottled part decreased, and the boundary of the chilled part became sharp. As the Si content was further increased above 1.7%, hardness of the alloys decreased until the chill disappeared. Specimens for mechanical tests of gray iron part of a chilled roll, were prepared as follows; the pig iron mentioned above was cast at 1280° C. in a mold which was preheated at 1200° C., and then cooled slowly. Structure of the gray cast iron thus prepared was similar to that of the central part of a chilled roll. Various amounts of Si up to 6.12% being added to the pig iron, 9 kinds of test specimens were prepared by the same method. Hardness of these gray cast irons decreased as Si content increased up to 2.5%, while the impact resistance increased, and the tensile strength was unaffected by Si up to 3%. The only effect of Si on a chilled roll is in decreasing the depth of chill. If a more effective chill method is developed a high Si chilled roll may be used. TS (11b)

Two New British Cast Irons Have Heat-Resisting Properties. A. L. NORBURY & E. MORGAN. *Iron Age,* Vol. 131, June 22, 1933, page 993. See "Silal and Nicrosilal Heat-Resisting Cast Irons," *Metals & Alloys,* Vol. 5, July 1934, page MA 358. VSP (11b)

Chromium Alloy Steel Castings. J. H. CRITCHETT. *Foundry,* Vol. 62, Jan. 1934, pages 16-18, 43. **Use of Chromium in Steel Castings as Surveyed at A. F. A. Meeting.** *Iron Age,* Vol. 131, June 22, 1933, pages 991-992. See "Chromium in Steel Castings," *Metals & Alloys,* Vol. 5, July 1934, page MA 358. VSP (11b)

High Test Cast Iron by Adding Fine Grained Chromium-Nickel (Hochwertiger Grauguss durch Zusatz von feinkörnigem Chrom-Nickel). *Zeitschrift für die gesamte Giessereipraxis,* Vol. 55, July 22, 1934, page 306. Discusses the advantages derived from the addition of Cr-Ni to high test cast Fe, in decreased sensitivity to varying wall thickness, improved mechanical properties, improved resistance to wear, heat and chemical agents and decreased tendency to growth. Cr-Ni is best added in finely divided form. A few analyses of Cr-Ni alloyed cast irons are given. In all of these castings the Si content is kept very low. GN (11b)

Strength of Open-Hearth Malleable Iron as Dependent on Wall Thickness (Festigkeit von Siemens-Martin-Ofen-Temperguss in Abhängigkeit von der Wandstärke). F. ROLL & KRITZLER. *Die Giesserei,* Vol. 21, July 20, 1934, pages 312-313. The classification of malleable iron into 2 types, one for white and one for black malleable iron is shown to be correct only for a definite diam. of sample. As white iron is not a homogeneous material, but depends largely on method of production and heat-treatment, the thickness of a casting has a great influence on its properties; the marginal zone has wrought-iron properties while the core corresponds to a harder steel. The composition should be adjusted to the wall thickness and this should be as uniform as possible. This relationship does not exist to such a pronounced extent in black malleable iron which has a ferrite matrix that is uniform over the whole section; above wall thicknesses of about 12 mm. strength and elongation are almost constant. Ha (11b)

Heat Conductivity of Cast Iron (Wärmeleitfähigkeit von Gusseisen). E. SOEHNCHEN. *Die Giesserei,* Vol. 21, July 20, 1934, page 311. An ice calorimeter method was developed to determine heat conductivity by comparing cast iron with a rod of electrolytic Ni. It was found that a mixture of ferrite and elementary C has a greater heat conductivity than a mixture of ferrite and cementite. The improvement obtainable by annealing depends on chemical composition and increases with increasing C content. Contrary to electrical conductivity which increased with the fineness of graphite, heat conductivity decreased with fineness of graphite. Additions to Fe-C alloys reduce heat conductivity if solid solutions are formed; however, it may be increased if the additions increase the graphite content. In general, all elements added, intentionally or unintentionally, to cast iron reduce heat conductivity, especially P and Cr, contrary to statements in the literature; addition of Ni with simultaneous decrease of Si increases heat conductivity. Ha (11b)

The Total Radiation of Iron in the Temper Color Region (Die Gesamtstrahlung des Eisens im Gebiete der Anlauffarbenn). R. HASE. *Archiv für das Eisenhüttenwesen,* Vol. 8, Sept. 1934, pages 93-96. The emissivity of low and high carbon steel and of cast iron samples, with the surfaces either polished or ground, was determined over a range of temperatures. The emissivity did not increase below 300° C., even after the formation of relatively dark temper colors. Between 300 and 450° C., however, there was a sharp increase as a thicker oxide layer formed. Above this the emissivity remained fairly constant at about 80 to 90% of a black body, so long as the oxide layer was not removed. Only at 1400° C., near the melting point, was there a falling off in emissivity as the oxide layer was dissolved and the surface of the metal was exposed. The emissivity increased at the lower temperatures only after the temper color oxide layer became 0.5 μ thick. To obtain uniform temperature measurements with a radiation pyrometer in the blue heat region the steel should be preheated at 450° C. to obtain an oxidized surface; otherwise radiation measurements in the region 300 to 400° C. should be avoided. SE (11b)

Anomalous Properties of New Magnetic Materials (Über anomale Eigenschaften neuer magnetischer Werkstoffe). MARTIN KERSTEN. *Wissenschaftliche Veröffentlichungen aus dem Siemens-Konzern,* Vol. 13, July 16, 1934, pages 1-9. Cold rolled Fe-Ni-Cu alloys, which are of practical importance because of their extremely low magnetic retentivity, were investigated by the "stress analysis" method; that is, their magnetic properties were studied under the action of applied mechanical stresses. Increasing Cu content produces an increase in the characteristic stress. Annealing tests show this is frequently caused by precipitation, as in precipitation hardening. The effect of cold rolling and annealing on magnetic retentivity was studied. Cold rolled strip with 12 to 15% Cu after annealing at 600° C. possesses a retentivity value nearly equal to the saturation value of magnetization. The Ni:Fe ratio in the base alloys to which Cu was added ranged from 45:55 to 40:60. MG (11b)

Investigations on High-Quality Rails (Untersuchungen an hochwertigen Schienen). R. KUEHNEL. *Zeitschrift Verein deutscher Ingenieure,* Vol. 78, July 21, 1934, page 893. Extracts from 5 reports of the Swiss Technical University in Zurich on high-grade Austrian and German rails. German rails designed particularly for safety against fracture and for low wear are made with extremely low C content but high Si and Mn with additions of Cr and Cu; also of a silicised C steel with Mo having more than 100 kg./mm.^{2} tensile strength. Austrian rails for low wear have 1.8-1.9% Mn and 95 kg./mm.^{2} tensile strength; care is taken to obtain a eutectoid, pearlitic structure. The material is made in the electric furnace. Another type is a compound of Cr steel with 0.75-1% Cr and 0.6-9.5% C. (Editor's note: This should no doubt read 0.95) in the railhead and a soft steel for foot and web; tensile strength more than 100 kg./mm.^{2} Ha (11b)

Dependence of Sulphur on Silicon in Cast Iron (Die Abhängigkeit des Schwefels vom Siliziums bei Gusseisen). F. ROLL. *Die Giesserei,* Vol. 21, Aug. 17, 1934, pages 349-350. Experiments with 15 different types of cast Fe showed that just as a certain ratio exists for total C to Si or combined C to Si, so also a certain ratio for S to Si exists. The curves (straight lines) showed

an upper ratio of: $\%S = 0.195 - 0.0264\ (\%Si)$
an average ratio of: $\%S = 0.162 - 0.0264\ (\%Si)$
and a minimum ratio of: $\%S = 0.138 - 0.0264\ (\%Si)$

Hematite pig Fe had an average of $\%S = 0.047 - 0.006\ (\%Si)$, valid for more than 1% Si. Slope and absolute values of these curves are greatly influenced by composition, e.g., Mn content. A diagram gives values for 0.8, 1.75 and 2.2% Mn. Ha (11b)

Cromansil Steel. *Marine Engineering & Shipping Age,* Vol. 39, Aug. 1934, pages 290-294. Additions of 0.40-0.60% Cr, 1.10-1.40% Mn, and 0.60-0.90% Si to a low C steel have given the best results in general use. The C content may be varied, depending on the physical properties desired. Where steel is to be cold worked, machined, or welded, most satisfactory results have been obtained with 0.15-0.25% C. A table shows physical properties of Cromansil steel in the "as rolled" condition obtained with different C contents (0.05% up to 0.46% C). Discussing in detail the application for structural purposes, advantages of Cromansil steel in working as well as in joining by riveting, oxyacetylene or arc welding are pointed out. Properties of Cromansil and other structural steels are compared. Kz (11b)

Molybdenum and Its Uses. L. SANDERSON. *Sands, Clays and Minerals,* Vol. 2, Aug. 1934, pages 33-36. Sources of supply, methods of preparation, and uses of Mo, especially in steels are described. Added in fractional percentages up to 1%, it has a beneficial effect on physical properties of mild structural steel. As compared with other alloy steels, Mo steels heat-treated to the same tensile strength, show a somewhat higher elastic limit, higher elongation and much greater reduction of area, and therefore greater ductility implying much greater toughness. The oxide scale from rolling and forging separates readily from the steel. The function of Mo in complex alloy steels is to prevent segregation, to promote uniformity of texture and to secure a high degree of toughness not present in other alloy steels. Mo is also used in steels of high strength at high temperatures. With an addition of 3-4% Mo to 18:8, a steel of maximum resistance to H_2SO_4 compared to any other ferrous alloy is obtained. Ha (11b)

Some Characteristics Common to Carbon and Alloy Steels. Edgar C. Bain. *Preprint American Iron & Steel Institute,* May meeting, 1934, 34 pages; *Steel,* Vol. 94, May 28, 1934, pages 25-29, 36 (abstract); *Iron Age,* Vol. 133, May 31, 1934, pages 29A-29H, 74, 76 (abstract). **The Role of the Common Elements in the Alloy Steels.** *Iron Age,* Vol. 133, Apr. 5, 1934, pages 26, 82. Carbon steel, in sections small enough to be hardened throughout, develops strength properties essentially as great as those of the low-alloy steels except that it is somewhat inferior in ductility and toughness. If the steel is softened to improve these properties, it is then slightly inferior to some of the alloy steels in strength. Practically all alloying elements contribute the property of deep hardenability which enables heavy sections to be heat-treated through and through as desired; this is due to the fundamental effect of alloying elements in retarding the transformation. Deep hardenability can never be properly acquired by plain carbon steel. Plain carbon steel may be made moderately deep-hardening by means of coarsening the austenite grain-size but this results in lower ductility and impact strength. Fine grain-size should therefore be retained and hardenability secured by alloying. The properties of steel are more directly and widely controlled by the structure than by any other means and this control is more easily obtained in alloy steels. Certain of the elements in alloy steel form carbide particles during tempering which coalesce very slowly. Since the dispersion remains fine the strength is retained after far higher reheating temperatures than in carbon steels. This appears to relate to creep strength. The carbide-forming elements by virtue of their stable, reluctantly-soluble carbide particles manage to offer great resistance to grain growth and hence, by proper heat-treatment they may contribute both deep-hardening characteristics and fine austenite grain. Similar characteristics may be secured by using an element such as manganese together with a deoxidation practice which likewise insures fine grain. In addition to the effect of the alloying elements to increase hardenability and to restrain grain growth, a moderate improvement results solely from the increased strength of the alloy-bearing ferrite matrix in both pearlitic and tempered steels. This is due to the effect of solid-solution hardness which, though mild, is at the same time accompanied by little loss in ductility. The table below gives the principal effects of the elements applying only to medium or high carbon steels in which there is ample carbon for combination with fairly large amounts of the carbide forming elements.

PRINCIPAL EFFECTS IN MEDIUM OR HIGH CARBON STEEL

Alloy Element	To Increase Hardenability	To Strengthen Ferrite	To Form Carbides, Decreasing Creep, Restraining Grain Growth	To Form Oxide Particles to Restrain Grain Growth
Mn	Strong	Strong	Mild	Weak
Si	Strong	Strong	No	Moderate
Cr	Strong	Moderate	Moderate	Weak
Ni	Moderate	Strong	No	No
Mo	Moderate	Weak	Strong	Weak if any
W	Moderate	Weak	Strong	Weak if any
V	Mild	Weak	V. strong	Prob. strong
Ti	Weak	Weak	V. strong	Prob. strong
Co	Weak	Strong	V. weak	No
Al	Moderate	Strong	No	Strong
Zr	Prob. weak	Weak	Moderate	Strong
Cu	Prob. weak	Moderate	No	No

VVK + MS + VSP (11b)

Coarse and Fine Grained Steels. R. L. Rolf. *Heat Treating & Forging,* Vol. 20, June 1934, pages 271-274; July 1934, pages 331-333. Investigated physical properties of (a) fine-grained steel containing 0.398% C, 0.74% Mn, 0.023% P, 0.030% S, and 0.19% Si, and (b) coarse-grained steel containing 0.402% C, 0.72% Mn, 0.020%P, 0.035% S, and 0.21% Si. 1" rounds were normalized at 1600° F., quenched in H_2O at room temperature from temperatures at 50° F. intervals between 1400° and 1600° F., and drawn at 1050° F. Another set was normalized at 1600° F., reheated to 1525° F., quenched in H_2O and drawn at 100° F. intervals from 800° to 1200° F. In both cases, tensile strength and yield-point of (a) were lower than for (b) but reverse was true regarding elongation and reduction of area. However, if (a) be drawn at temperatures 50°-100° lower than (b), equivalent tensile strengths may be obtained with greater ductility, but with greater surface hardness. In the quenching series, resistance to impact of (a) was high and fairly uniform throughout the entire quenching range; values for (b) were low and varied. In the tempering series, impact values for (a) were high and for (b) low. Starting at 1000° F., both showed a decided increase in impact strength which advanced with drawing temperature. Compared on the basis of equal tensile strength, yield-point of (a) is lower than that of (b) between 100,000 and 116,000 lbs./in.^{2}; (a) is higher between 116,000 and 120,000 lbs./in.^{2}, and (a) is lower above the last value. Elongation is about the same for both steels at all strengths. Reduction of area is about the same up to 120,000 lbs./in.,^{2} beyond which (a) has greater ductility. Izod impact values for (a) are superior at all strengths. Brinell hardness is about the same up to 116,000 lbs./in.,^{2} beyond which (a) becomes somewhat harder. Plotting H. T. Chandler's Merit Index against yield-point shows a superior Merit Index for (a) for any strength, although at the lower yield-points, these values are nearly equal for both steels. Hardenability tests showed that (a) does not harden as deeply as (b). Surface hardness obtained for the various quenching temperatures varied less with (a) than with (b). Specimens of (a) could be bent flat at all drawing temperatures. At low drawing temperatures, (b) showed very erratic results, but could be bent flat when drawn above 1000° F. MS (11b)

Properties of Cromansil Steels for Structural Purposes. W. B. Miller. *Steel,* Vol. 94, May 21, 1934, pages 32, 34-35, 50. Paper read before the American Institute of Steel Construction, Inc., Oct. 19-21, 1933. Cromansil steels contain 0.4-0.6% Cr, 0.9-1.2% Mn, and 0.7-0.9% Si. C content may be varied widely depending upon use to be made of the steel. Material possesses high strength and ductility in the as-rolled condition at low cost. Transverse and shearing strengths are very high for any tensile strength. Desired properties may be obtained without heat treatment by selection of appropriate % of alloying elements and C. Fatigue limit is about 60% of the ultimate strength. Simple heat treatment results in a better combination of strength and ductility than for any form of C steel. Typical properties are as follows: center of 2 x 2 in. bar containing 0.32% C, 0.46% Cr, 1.07% Mn, and 0.44% Si, in the as-rolled condition, had a yield-point of 65,000 lbs./in.^{2}, ultimate strength of 99,000 lbs./in.^{2}, elongation in 2 in. of 27%, reduction in area of 64%, and Brinell hardness of 200-220. Fabrication and working, including threading and welding, are not essentially different than with ordinary C steel. Material does not harden markedly during welding and flame cutting. Gives results of tests by A. E. Gibson on Cromansil steel rivets (see *Metals & Alloys,* Vol. 5, July 1934, page MA 339). MS (11b)

Future Research on Alloy Steels. J. H. Andrew. *Metallurgia,* Vol. 11, Nov. 1934, pages 1-6. General discussion of the different alloy steels now available. JLG (11b)

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Ruptures and Failures of Rails (Ruptures et avaries accidentelles des rails). J. Merklen & E. Vallot. *Génie Civil,* Vol. 104, May 1934, pages 400-404, 420-422. Description of the usual defects of rails, causes and means for prevention of failures and testing methods used by Belgian and French railroads. JDG (11b)

Some Notes on Manganese in Straight Carbon Steels of Hardening Quality. Glyn Powis. *Metallurgia,* Vol. 10, Oct. 1934, pages 179-180. Points out importance of Mn content in steels that are to be quenched. Optimum Mn content depends on C content, section, method of quenching, and depth of hardness desired. JLG (11b)

Ferrous Metallurgical Developments During Past Five Years. H. S. Rawdon. *Metals & Alloys,* Vol. 5, Oct. 1934, pages 207-212. Metallurgical developments in the fields of stainless steel, welding, wrought iron, C steel, tool materials, cast Fe coatings and corrosion, heat treatment, working of steel, melting and technical information on the properties of steel are described. WLC (11b)

Recent Studies on Mild Steels (Etudes Récentes sur les Aciers Doux) J. Seigle. *La Technique Moderne,* Vol. 26, Jan. 1, 1934, pages 1-6. Subjects covered are as follows: (1) steel, puddled iron and rust; (2) cold working and aging after cold work; (3) size of ferrite grains in normal, mild steels; (4) brittleness of mild steels due to cold working (so-called "cold working sickness" due to very coarse grains after annealing); (5) single crystal of soft steel; (6) brittleness in boiler plate due to alkaline water. FR (11b)

Some Physical Properties of Cast Iron (Sur Quelques Propriétés de la Fonte. E. Söhnchen. *Bulletin de l'Association Technique de Fonderie,* Vol. 8, July 1934, pages 335-344. Paper presented at the Nancy Foundry Congress, July 1934. Magnetic properties, thermal conductivity, electrical resistance, and thermal expansion of cast Fe studied with special reference to new alloys, such as Ni-Resist, Silal, Nicrosilal, and Nomag. These alloys, by their special properties, have opened new fields for the use of cast Fe. 13 references. WHS (11b)

Influence of the Oxyacetylene Weld on the Mechanical Properties of Tubes in Aeronautical Construction (L'Influenza della saldatura ossiacetilenica sulle caratteristiche meccaniche dei tubi per costruzioni aeronautiche). G. Calbiani. *La Metallurgia Italiana,* Vol. 26, June 1934, pages 404-419. Tensile and elongation tests were made on samples of carbon, chromium, and molybdenum steels, used as tubing in airplane construction, welded by means of the oxyacetylene flame. Elongation values are not reliable as the thickened joint interferes with the flow of the metal. Tubes heat-treated so that the elongation was increased as much as 250%, showed a constant elongation value at the welded zone. Thus tests of welded joints give a measure of the breaking strength only, not the elongation. AWC (11b)

Hardness, Deflection and Strength in Cast Iron Rolls (Härte, Durchbiegung, und Festigkeit bei gusseisernen Walzen). E. Scharffenberg. *Die Giesserei,* Vol. 21, July 6, 1934, pages 287-291. Literature on relation between hardness and strength of cast Fe is reviewed. When testing cast Fe rolls, samples must be taken from the casting itself. Hardness of the surface and strength of the "carrying layer" (i.e. the layer of the material on which the hardened layer rests) have an inverse relation. Each piece has an optimum hardness-strength combination; there is a maximum in the strength-hardness curve. Deflection at fracture was, within groups of equal strength, greatest at low hardness and decreased with increasing hardness. Ha (11b)

Properties of Ferromagnetic Alloys of the Ternary System Iron-Nickel-Vanadium (Ueber die Eigenschaften der ferromagnetischen Legierungen des ternären Systems Eisen-Nickel-Vanadium) H. KUEHLEWEIN. *Zeitschrift für anorganische und allgemeine Chemie,* Vol. 218, May 18, 1934, pages 65-88. 3 principal ranges are distinguished in the Fe-Ni-V alloys up to 30% V: 1. solid solutions of the body-centered type (α-lattice); 2. solid solutions of the face-centered type (γ-lattice); 3. heterogeneous range with α-and γ-solid solutions. Alloys with more than 30% V show a new lattice, the structure of which could not be determined with certainty by X-ray examination. Sp. gr. and electric resistance are given in diagrams. Structure of the ternary system is similar to that of Fe-Ni alloys. The Curie point is lowered in the γ-range of the Fe-Ni series by about 40° C. for each 1% addition of V. Alloys in the range of permalloy composition possess high initial and comparatively low, maximum permeability, with high specific electric resistance. Additions of 0.05% P, or 0.1% Si, and also 0.5% Be improved workability of the alloys considerably but adversely affected magnetic properties. An addition of 0.1% C improved workability without seriously decreasing permeability. Influence of heat treatment and alloys with 80% Ni and 1-10% V were specially investigated. Ha (11b)

Factors Determining the Impact Resistance of Hardened Carbon Steel. HOWARD SCOTT. *American Society for Metals Preprint* No. 13, 1934, 23 pages. Impact tests of fully hardened and tempered steels of medium C are reported. Charpy type specimen with special ground notch was used. No maximum in impact resistance at low tempering temperatures was found. Complete solution of ferrite is essential for full development of impact resistance. All steels tested, 34 in number, fall into classes: laboratory-melted steels deoxidized only with Mn and Si fall in low-impact class; those to which 0.06% Al was added fall in high-impact class. In larger amounts V has same effect as Al on impact. Mn increases impact value of Al treated steels when varied from 0.6 to 1.0%. Al treated steels are fine grained while those without Al or equivalent treatment are coarse and low in impact value. Steels made from highly purified iron, low in O_2 content, are fine grained with Al and V additions; without Al or V, extreme grain-size contrast is developed on heating slightly above Ac_3. Purified alloys are shallow-hardening and possess low impact resistance unless Al or equivalent additions are made. High purity tends to eliminate directional effects and irregular distribution of ferrite. 14 references. WLC (11b)

The Value of Young's Modulus for Steel. H. H. ABRAM. *Iron & Steel Industry,* Vol. 7, June 1934, pages 302-303. Abstract of paper read at annual meeting of Iron & Steel Institute. See *Metals & Alloys,* Vol. 5, Sept. 1934, page MA 458. CEJ (11b)

Steel Ingots. N. H. BACON. *Iron & Steel Industry,* Vol. 7, June 1934, pages 309-311. Ingots must be designed for the purpose for which the steel is to be used. Ingots may be divided into 3 classes, namely: fully piped, balanced and effervescent. It is possible to produce from one ladle of molten metal, ingots of each type of steel ranging from effervescent to fully piped. A molten steel containing 0.10% C, no Si and 0.40% Mn will effervesce freely when poured into molds, but if a deoxidizer, for example Al, be added in amounts of 2 oz. per ton the effervescence will not be so vigorous and a rimmed ingot will result. Increase of the Al addition to 8 oz. per ton of molten metal will almost eliminate effervescence. With 16 oz. per ton addition of Al the steel will be quiet in the mold. Effervescing steel is particularly suitable for strip and deep stamping of pressing operation. Limiting range of analysis: C, 0.25% max.; Mn, 0.60%; Si, none. Balanced steel is made where there is demand for a cheap billet and the analysis puts the effervescing type outside the specifications; analysis: 0.1-1.0% C, 0.08-0.12% Si; and 0.6-0.7% Mn. A steel which contains 0.2% Si; and 0.7% Mn should be full piping. CEJ (11b)

The Elasticity, Deflection and Resilience of Cast Iron. J. G. PEARCE. *Iron & Steel Industry,* Vol. 7, June 1934, pages 307-308. Abstract of paper read at the annual meeting of the Iron & Steel Institute. See *Metals & Alloys,* Vol. 5, Oct. 1934, page MA 494. CEJ (11b)

The Thermal Conductivity of Tool Steels. DENZABURO HATTORI. *Iron & Steel Industry,* Vol. 7, June 1934, page 302. Abstract of paper read at annual meeting of Iron & Steel Institute. See *Metals & Alloys,* Vol. 5, Sept. 1934, page MA 458. CEJ (11b)

The Influence of Beryllium on Steel. J. H. S. DICKENSON & W. H. HATFIELD. *Iron & Steel Industry,* Vol. 7, Mar. 1934, page 206. Abstract of paper presented at meeting of Iron & Steel Institute. See *Metals & Alloys,* Vol. 5, May 1934, page MA 225. CEJ (11b)

Tentative Specifications for Steel for Bridges, Buildings, and Mild-Steel Plates. *Engineering,* Vol. 137, May 25, 1934, page 607. Short summary of three tentative standards recently issued by the American Society for Testing Materials. LFM (11b)

Report of Sectional Committee on Specifications for Cast Iron Pipe, 1932. *Journal American Water Works Association,* Vol. 26, Mar. 1934, pages 379-382. This committee functions under the American Standards Association. Progress report of Technical Committee on 1, Dimensions; 2, Metallurgy, Processes and Tests; and 3, Corrosion and Protective Coatings. VVK (11b)

A Rapid View of Stainless Steels. *Metal Progress,* Vol. 26, Oct. 1934, pages 23-26. Development of large applications of both ferritic Cr, austenitic Cr-Ni stainless for buildings, railroad rolling stock, and automotive uses are discussed, together with effects of additions of Mo, Ti, and Se to standard compositions. WLC (11b)

Carbon Steels for Bars, Rods, Sheet and Strip. *Metal Progress,* Vol. 26, Oct. 1934, pages 32-36. Developments in knowledge of effects of grain size upon physical properties and response of C steel to heat treatment are discussed. Hot rolling practice has been improved so that tolerances on rounds as low as 0.001″ are accepted. Quality of sheet and strip for drawing purposes has been improved and controlled. Control of age hardening characteristics or stabilization of such steels is discussed. WLC (11b)

Advancement in Low and Medium Alloy Steels. *Metal Progress,* Vol. 26, Oct. 1934, pages 5-10, 12. Discusses improvements in quality and knowledge of S.A.E. alloy steels. Grain size effects and the utility of such alloys as Ni, Mo, Cr, V and Cu alone and in several combinations are discussed. Some physical properties are given. WLC (11b)

Periodic Fluctuations in Metal. E. G. HERBERT. *Metallurgia,* Vol. 10, Sept. 1934, pages 153-154. From paper given before British Association. Periodic fluctuations were observed in the modulus of elasticity of steel wire. Fluctuations decreased in intensity when the sample was shielded from magnetic fields. JLG (11b)

Why Springs Have Their "Set" Removed. F. HINTZ. *Machinery,* N. Y., Vol. 41, Nov. 1934, page 164. The ultimate elastic limit of a spring is increased by stressing it beyond its original elastic limit, thus giving it an initial permanent deformation. Treatment and determination of the dimensions of springs to obtain this end are described. Ha (11b)

EFFECT OF TEMPERATURE ON METALS & ALLOYS (12)

L. JORDAN, SECTION EDITOR

The abstracts in this section are prepared in co-operation with the Joint High Temperature Committee of the A.S.M.E. and the A.S.T.M.

Qualifications of Steels for High Temperature Service in Petroleum Refinery Equipment. Factors influencing Creep of Alloy Steels Used in Refinery Equipment at High Temperatures. A. E. WHITE, C. L. CLARK & R. L. WILSON. *Oil & Gas Journal,* Vol. 33, Aug. 2, 1934, pages 16, 18-19, 51; Aug. 9, pages 16, 33-34, 36. The first article discusses the general requirements for steels for high temperature refinery service with particular reference to creep strength, short-time tensile properties, impact resistance and corrosion and oxidation. The following data are given in the form of curves: time-elongation and creep-stress curves at 1000° F. for a Cr-W-Si-V steel; short-time tensile and stress-strain curves for Mn-Mo steel up to 1400° F. and the effect of temperature on Charpy impact resistance of a Cr-Mo steel. The second article gives creep data on pearlitic alloy steels. In a series of Mn-Mo steels, varying only in Mn from 1 to 3%, the highest creep properties are shown by the alloy containing 1.25% Mn and the lowest by the 2.99% Mn steel. 1000 to 1200° F. is virtually the limit of practical application of the pearlitic steels for low rates of creep but these steels are subject to oxidation and scaling. Such steels should be calorized to reduce oxidation. For higher temperatures the highly-alloyed austenitic steels should be used. Melting practice and deoxidation have an important effect on the creep properties of steels. "Killed" open-hearth C steel has a greater creep resistance at 900° and 1000° F. than "open" open-hearth C steel although there is only a small difference in the strength of the steels at 800° F. At temperatures 1000° F. or higher the quenched and tempered condition showed the lowest creep resistance, the normalized and tempered condition the highest with the annealed steel between the other two. At temperatures below the lowest temperature of recrystallization fine-grained material possesses the better creep resistance while at higher temperatures the coarse-grained structure has the greater resistance to creep. While the coarse-grained steels are not enough stronger than the fine-grained in the important range of industrial temperatures to urge a preference for coarse-grained steels, yet the fine-grained steels do not coarsen as rapidly at forging temperatures and are tougher and more ductile at atmospheric temperature. Cold-working increases creep. Comparing hot-rolled with cold-worked material, the hot-rolled material had the highest creep resistance at 600°, 850° and 1000°F., the difference being slight at the first-named temperature, somewhat larger at the second and considerable at the third. Intermittent heating alone and intermittent heating in conjunction with intermittent loading had no significant effect on the normal creep of a steel at 850 or 1000°F. VVK (12)

Investigation of Steels used for Valves of Explosion Motors, and their Properties at High Temperatures (Ricerche sugli acciai per valvole di motori a scoppio e sulle loro caratteristiche alle temperature elevate). Part I. I. MUSATTI & A. REGGIORI. *La Metallurgia Italiana,* Vol. 26, July 1934, pages 475-498; Aug. 1934, pages 569-599; Sept. 1934, pages 675, 689. The high temperature properties of a series of 15 valve steels are determined, viz. 1) the resistance of creep; 2) resistance to repeated impacts; 3) resistance to the oxidizing action of the exhaust gases; 4) the changes in structure and in static and dynamic properties, hot or cold, caused by prolonged exposure to high temperature. A temperature range of 500°-900°C. was used. Furnaces used maintained the desired temperature within 0.2° even with fairly wide fluctuations in current. It is difficult to find a steel which will satisfy all the requisites for a good valve steel. In general, the best results are obtained with austenitic steels, containing high Ni and Cr, several % of W, and from 1-2% of Si. High Ni and Cr (up to 33% Ni and 20% Cr) alone are not enough to insure good mechanical properties at high temperatures; these are imparted by the further addition of W. Replacing the W with Mo does not help. Next to these austenitic steels in quality are the silchrome steels containing several % of Mo or W. These are very similar to the Ni-Cr. High-speed tool steels or high-Cr steels with additions of Co, Al, or Mo, are all decidedly inferior to the preceding types. Large additions of Ni to the high-speed steel are not satisfactory as the resulting alloy has poor resistance to corrosion. AWC (12)

Using Dry Ice in Assembling Motor-car Valve Seats. *Machinery,* London, Vol. 44, June 28, 1934, pages 371-372. Rings of a hard, tough cast alloy that serve as seats for the exhaust valves are shrunk about 0.0025″ in dry ice refrigerators. Contracted they are from 0.001″-0.0015% larger in diameter than the recessed holes into which they are fitted. They are driven into the holes with two light hammer blows. Distortion of cylinder blocks is eliminated by this method. Description of the assembling operation and of the refrigerators in which the rings are cooled down to at least 90°F. below zero. Kz (12)

Use of Long Time Creep Test Data in the Design of Heat Enduring Castings. B. J. SAYLES. *Industrial Heating,* Oct. 1934, pages 41-46. Creep is defined. The measurement of creep, methods of shortening the testing time, and the application of results to the control of composition, heat-treatment and working of a metal are described. Ha (12)

The High-Temperature Hardness of Iron and Steel. MATSUJIRÔ HAMASUMI. *Kinzoku no Kenkyu,* Vol. 11, June 20, 1934, pages 263-273. A new high-temperature hardness tester has been applied to measuring, in vacuum and at various temperatures, the hardness of Armco iron, 0.1-1.2% C steels, high-speed steel and some special valve steels. The new tester consists of a double-walled glass cylinder, the inner wall having a graduated scale on its surface. A small heating furnace made of a quartz shell and W-filaments is hung in the glass cup which fits tightly on the outer glass cylinder. The test specimen, a ball 8 mm. in diameter, is hung by a fine manganin wire at a constant height in the furnace. When the specimen has attained a desired temperature, the manganin wire is fused by an electric current and the ball specimen drops on an anvil of white cast iron in the bottom of the glass cylinder. The height of the rebound is measured on the scale on the inner cylinder. This reading is taken as the hardness number. The apparatus is so highly evacuated by a mercury diffusion pump that oxidation of the test ball is completely prevented. The hardness of C-steels tested decreased gradually as the temperature increased to 500°, but attained a maximum at 600° due to the blue-brittleness of iron. The relation between the hardness number h and diameter d of indentation made on the ball surface is expressed by an equation, $hd^m = C$, in which m is a constant not depending on the steel quality, and C, another constant depending on the steel quality. TS (12)

The Interpretation of Creep Tests. P. G. MCVETTY. *Preprint for the June 1934 meeting of the American Society for Testing Materials,* 12 pages. This paper discusses the fundamental nature of the creep curve and the probable effect upon it of strain-hardening, annealing, age-hardening, and other phenomena associated with the long exposure of complex alloys to stress at elevated temperatures. The possible effects of "creep-recovery" are mentioned. Examples are given to show how, under suitable conditions, published creep data may be correlated. An attempt is made to stimulate interest in the general subject of interpretation of creep data in the hope that a more intensive study will develop better methods than those commonly used. VVK (12)

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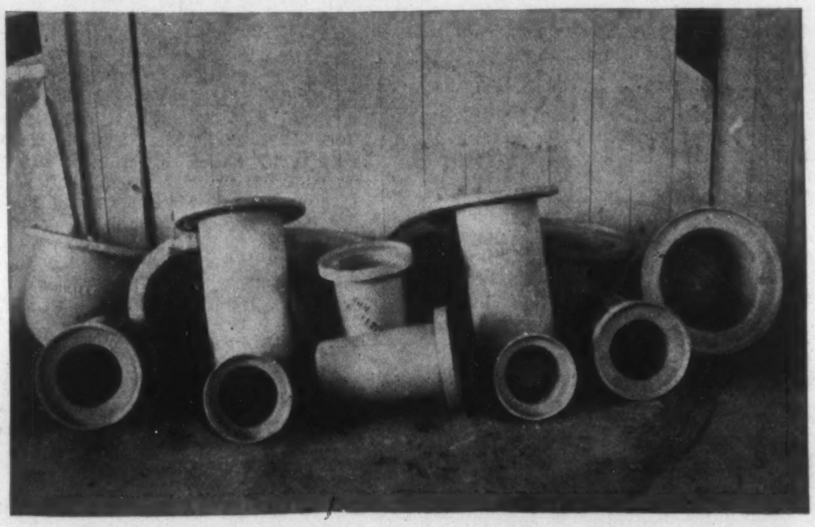

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CORROSION & WEAR (13)

V. V. KENDALL, SECTION EDITOR

Relation between Structure and Wear Resistance of Iron Alloys as Measured in a Spindel Machine (Zusammenhaug zwischen dem Gefügeaufbau der Eisenlegierungen und ihrem Verschleiss bei der Prüfung nach M. Spindel). W. Köster & W. Tonn. *Archiv für das Eisenhüttenwesen,* Vol. 8, Sept. 1934, pages 111-115. Wear tests of various alloys were made in a Spindel machine and the relation between wear and structure studied. In α alloys of Fe with W, Mo. and Al the wear was inversely proportional to the Brinell hardness. In γ alloys there was less relation between Brinell hardness and wear. In heterogeneous steels, Fe-Mo, and Fe-W alloys the wear slowly decreased with increase in alloy content. In annealed C steel raising the C to 1.6% lowered the wear only 15%, but in sorbitic steel the wear decreased greatly. In martensitic Fe-Ni and Fe-Mn alloys the wear decreased with increasing alloy content until they became austenitic. In hardened C steel the wear reached a minimum at 0.45%C and then remained constant with increasing C content. Age-hardening in Fe-W and Fe-Mo alloys had little effect on wear. Cold working, even though it increased the hardness considerably had little effect on wear. SE (13)

Properties of Corrosion Resisting Chromium-Manganese and Chromium-Nickel-Manganese Steels (Eigenschaften von nichtrostenden Chrom-Mangan und Chrom-Nickel-Mangan-Stählen). I. S. Günzburg, N. A. Alexandrova & L. S. Geldermann. *Archiv für das Eiscnhüttenwesen,* Vol. 8, Sept. 1934, pages 121-123. Forty melts were made to study the effect of substituting Mn for the Ni in 18-8. Ni is twice as strong as Mn in forming austenite; in straight Cr-Mn steels a pure austenitic structure was not obtained even with 16% Mn; however, austenite was obtained with 7% Mn and 2% Cu, and with 2% Mn and 6% Ni. The mechanical properties of these steels were not much different from 18-8, but the corrosion resistance was less; here an addition of 2% Cu was very beneficial. Against attack by sulphurous gases at high temperatures the Mn rich Cr-Mn steels were better than 18-8. SE (13)

Construction of Hot Water Boilers with Special Consideration of the Water Conditions (Richtlinien für den Bau von Heisswasserspeichen unter Berücksichtigung der Wasserverhältnisse). P. Fischer. *Elektrizitätswirtschaft,* Vol. 33 June 30, 1934, pages 248-251; July 31, 1934, pages 283-286. The destructive action of water on metallic containers is largely ascribed to the presence of CO_2 and O_2 in the H_2O. 4 mg.O_2/liter are aggressive in soft water. while 9 mg.O_2/liter are often ineffective in hard water. Protective coatings are dismissed as of little use, since a local attack cannot be entirely excluded. Local elements come into play if the metallic material shows great structural differences or if gas bubbles produce a differential aeration. The best rust protection of steel is furnished by Zn. O_2 attacks the Zn coating locally and CO_2 uniformly. Since Zn thereby goes in solution, Zn coatings are prohibited for containers carrying water for drinking purposes. Cl in hot water boilers also exerts a destructive action which reaches a maximum at 80°C. Sn is acid-proof but cannot be secured in sufficiently dense coatings. Due to pores local element destruction becomes more pronounced than with no Sn coating at all. Cu is highly resistant to hot water but forms soluble compounds. For household purposes, a Sn coating is therefore utilized. Cu and Sn are close together in the e.m.f. series, thus excluding electrolytic action in acideous water. Occasional corrosion is ascribed to the use of hard Cu sheet into which cuprous oxide has been rolled in. A potential difference between the latter and Cu results. Since hard or medium hard Cu sheets must be used in high pressure boilers, the absence of Cu_2O must be ascertained. Pb and Pb bearing Sn should not be utilized as coating material for Cu. The higher the O_2 content of the H_2O the faster Pb goes into solution. No attack occurs if O_2 is entirely absent. CO_2 becomes aggressive only in the presence of O_2. Brass should not be used as boiler material due to danger from local element corrosion. Bronze is well suited. Ni is too expensive and does not have the corrosion resistance to CO_2 and O_2 as generally taken for granted. Enamel coatings cannot follow the "breathing" of boilers. Cracks develop due to the boiler pressures and temperature drops (cold feed water). Cr plated steel and stainless steel yielded unfavorable results formerly due to respectively incomplete coat and corrosion at the joints. Al of 99.4% is highly corrosion resistant unless in contact with other metals, but cannot be applied in the case of higher pressures. WH (13)

Wear of Metallic Materials by Rubbing Oxidation and the Question of the Origin of Fatigue Fractures (Die Abnutzung metallischer werkstoffe durch Reiboxydation. Zur Frage nach der Entstehung des Dauerbruchs). Max Fink & Ulrich Hoffmann. *Metallwirtschaft,* Vol. 13, Sept. 7, 1934, pages 623-625. It is known that wear of metals is a chemical-mechanical process, as it takes place much faster in the presence of O than in its absence. The dust resulting from wear contains metallic particles and their oxides. Mechanical working of a metal causes the atoms near the surface to become very active chemically, which furthers oxidation of the surface and diffusion of O in the metal. Repeated alternate stresses in a metal subjected to fatigue also produce active zones at critical points, such as notches or weak spots. Rubbing oxidation then takes place, gradually penetrating farther into the metal, and eventually causing a fatigue fracture. This explains why the fatigue strength of metals is higher in non-oxidizing and lower in corrosive atmospheres than in air. 10 references. CEM (13)

Corrosion of Aluminum. José M. Fernández-Landreda. *Anales de la sociedad española de fisica y quimica,* Vol. 31, Nov. 1933, pages 776-778. In Spanish. After cleaning with a metal brush, Al was provided with a protective film by dipping into a bath (40°C.) comprising 150 g. $NaHCO_3$/liter and 250 g. NaCl/liter for 45 min. followed by washing in 25% KOH solution. Degreasing of Al wire can be accomplished electrolytically in a bath of 80 g. Na_2CO_3/liter and 18 g. NaCN/liter. Voltage = 8-10 volts, current density = 0.2 amps./dm.^{2}, anode = .2 C steel. On Al wire of 1 mm. or less oxidation is secured in 10 min. through the agency of a bath which contains per liter: 125 g. Na_2CO_3, 8 g. Na_2CrO_4, 25 cc. conc. NH_4OH. Temperature of bath = 50°-60°C. Ordinarily the following bath is recommended for electrolytic oxidation: 25 g. oxalic acid/l. 17 g. $Na_2C_2O_7$/l., 3 g. Na_3PO_4/liter. Temperature = 20°C., voltage = 12 volts which are raised to 15 volts during the last 5 minutes. WH (13)

Rust Protective Technique Abroad (Aus der ausländischen Rostschutztechnik). *Technische Blätter der deutschen Bergwerkszeitung,* Vol. 24, May 20, 1934, pages 306-307. Paper considers (1) methods of improving and accelerating phosphate coating method by addition of Cu, method of Parker Rust Proof, Amsterdam, that improves such coatings by subsequent treatment of coating with chromic acid, (2) method of Pacz in which Mo compounds are added to phosphate bath for improving and intensifying coating action, (3) method developed in France for making Ti coatings on Fe, (4) electrolytic Waldberg method of Ni coating, (5) testing of Ni deposits as suggested by Millot. GN (13)

Treatment Inhibits Metal Corrosion. *Steel,* Vol. 95, July 2, 1934, pages 32, 47. Describes Loxal method developed by Leo P. Curtin and marketed by the Curtin-Howe Corp., New York. MS (13)

Causes of Liner Wear. *Motor Ship,* Vol. 15, July, 1934, page 133. A practical experimental method of testing to show whether liner wear is due to corrosion produced by products of fuel combustion or to the mechanical action is briefly described. JWD (13)

Developments in Heat and Corrosion Resisting Castings. *Metal Progress,* Vol. 26, Oct. 1934, pages 51-56. Classifications of these alloys by Code Authority are given and diagrams show locations of various groups in Ni-Cr-Fe system. High temperature and corrosion resisting properties are discussed and some values of physical properties given. References are made to more details elsewhere. WLC (13)

Corrosion Research in Holland. *Journal Society Chemical Industry,* Vol. 53, June 29, 1934, pages 564-567. The Dutch Corrosion Committee, formed in 1931 by the Stichting voor Materiaalonderzoek (Research Institute for Materials), carries on its corrosion research through Committee II for studying the corrosive effect of soils on pipes, Committee III for studying the corrosive effect of soils on cables and Committee IV for studying protective coatings as applied to steel structures. Committee II is examining samples of pipes, soils and ground water from various places in Holland, determining periodically losses in weight of several kinds of iron buried in different types of soils, determining effect of bacteria and will extend their studies to include corrosion and protection of both iron and lead pipes. Committee III from its investigation has concluded that the use of tar is to be considered the primary cause of the corrosion of lead sheathings and suggests that all protective coatings be free from phenol, be impermeable to water and be physically stable. Committee IV is conducting an investigation on 40 different compositions of paints for open air protection of steel and has established contact with the British Corrosion Committee so that some of the standard painted specimens of the latter will also be exposed on the Dutch corrosion fields. VVK (13)

Second Report of the Corrosion Committee. *Iron & Steel Institute, Special Report* No. 5, May 1934, 293 pages. Section A outlines the work accomplished and proposed and reviews the First Report. Section B, by J. C. Hudson, describes the committee's field tests and reports on results obtained to date. The samples have not been exposed long enough to give much indication of the corrodibility of the metal, but some indications of quality of paints have been obtained. Red Pb applied as an undercoat to red oxide gave excellent results on steels, but a mixed-pigment paint containing red oxide and Zn chromate proved very satisfactory at one location. Section C deals with corrosion of ship's hulls. The subject is fully discussed and examination of some hulls is reported. The condition of hulls when first painted is considered to be of great importance. Some tests have been begun on corrosion of barge plates. Section D deals with laboratory corrosion tests. Part 2, by W. A. W. Schroeder, describes an automatic apparatus for laboratory tests by the intermittent spray method. Part 3, by W. H. Hatfield, deals with an evaluation of the proposed laboratory method. Part 4, by U. R. Evans, describes a study of zonal corrosion in wrought iron. Part 5, by H. Sutton, contains results of some tests on sheet and strip. Part 6, by C. E. Homer, is in reference to influence of non-metallic inclusions on corrosion of mild steel. Part 7 is a report from the National Physical Laboratory on the X-ray examination of rolling scale. Part 8, by J. W. Jenkins A. B. Winterbottom, and T. W. Lewis, describes a metallographic examination of rolling scale. Part 9, by J. C. Hudson, contains some data on field tests of specimens in the form of wire. Part 10, by J. C. Hudson, is in reference to paint tests of exposed materials. Section E is a summary of papers, memoranda, results, and other information submitted to the Committee. JLG (13)

Research on Cylinder Wear. *Engincer,* Vol. 158, July 27, 1934, pages 97-98; Aug. 3, 1934, pages 111-112; *Engineering,* Vol. 138, July 27, 1934, pages 103-105; Aug. 17, 1934, pages 182-184. From report issued by the Research and Standardisation Committee of the Institution of Automobile Engineers. LFM (13)

Zinc Used to Protect Yacht Hulls. *The Metallizer,* Vol. 2, Aug. 1934, page 1. To prevent corrosion the steel hull of a yacht was sprayed with zinc, then painted for decorative purposes. The same procedure for corrosion protection is applicable to various parts of ships, buoys, air craft pontoons and the like. BWG (13)

How Sulphide Corrosion is Prevented in West Texas Gasoline Plants. John C. Albright. *National Petroleum News,* Vol. 26, Jan. 24, 1933, pages 29-34. Corrosion of steel and brass equipment of the Big Lake and Artesian fields is due to hydrogen sulphide in the oil. The hydrogen sulphide content is very high in Crane and Ector Counties in Texas and Hobbs in New Mexico, Crane County gas showing an average hydrogen sulphide content of 50 grains and sometimes 70 grains corresponding to more than 11% by volume. The Phillips Petroleum Co. took the following measures to combat this condition. Rods, shafts and valves of pumping equipment were made of chrome or stainless steel. All gates, valves and stop cocks were specified as lubricated cast-iron plug valves or the gates must be steel with stainless seats, discs or needles. Wall thickness was almost doubled for stills, absorbers, and rectifying columns. For heat exchangers, seamless drawn and cast pure Al shells, tubes, tube sheets and return bends were specified. No attempt has been made to treat the gas used for fuel in the boilers. When the temperature of combustion is maintained as in continuous service there is no visible corrosion on the stack but when the unit is shut down and the temperature drops below the dew point, corrosion ensues. Plants are cleaned up twice a year. VVK (13)

Reconditioning Tanks in Sulphurous Districts is Being Undertaken by Pipe Line Companies. L. E. Bredberg. *Oil & Gas Journal,* Vol. 32, May 3, 1934, page 12. The Gulf Pipe Line Co. reconditions tanks by cleaning and repairing and then painting roofs inside with a special compound, by placing breathers in the very top of the roof and by covering bottoms with ¼″ coating of asphalt followed by a 1/16″ layer of sand and cement and 3½″ of water. VVK (13)

Trend of Future Pipe Line Construction Reflected by Study of Methods of Modern Crews. L. G. E. Bignelli. *Oil & Gas Journal,* Vol. 32, May 3, 1934, pages 15, 35-36. **Present Pipe Line Construction Features Use of Reconditioned Pipe and Protective Coatings.** May 10, 1934, pages 41, 197. The use of machines in reconditioning pipe lines especially of the Stanolind Pipe Line Co. system in Kansas. VVK (13)

Evaporation and Corrosion Practically Eliminated in Oil Field Pipe Line Gathering Equipment. L. G. E. Bignell. *Oil & Gas Journal,* Vol. 32, Apr. 13, 1934, pages 13, 87. The Wiggins Vapor Gathering Steel Balloon system is designed to provide ample space above the fluid in the tanks and additional space in a steel balloon to permit all of the vapors or gases produced in the tanks to expand and contract without any of the gas or vapor venting to the atmosphere. The balloon tank described has a capacity of 168,000 cu. ft. The crude oil handled contains appreciable sulphur and the gas accompanying it is high in H_2S but to date, after about 5 months, no corrosion has developed. The steel balloon bottom was painted with red lead and the roof with heavy grease. VVK (13)

Atmospheric Tests of Thin Sheets of Soft Steel (Ueber die Bewitterungsversuche mit Feinblechen aus weichem Stahl). F. EISENKOLB. *Korrosion & Metallschutz*, Vol. 10, July 1934, pages 161-166. The effects of different atmospheric conditions were investigated on 9 mild steels of different compositions; the samples were exposed to atmospheric influences in 8 locations of widely differing nature of surrounding air (railroad, smelter, mine, steelworks, forest, etc.) Tests and results are described fully and show in all cases the superiority of Cu steels; the useful effect of Cu is still enhanced by a small addition of Mo. Conspicuous was the bad behavior of very pure steels; this, however, might be due to oxidic impurities which at present are still very difficult to determine. The influence of surroundings is particularly felt where chemical attacks can occur; the steel industry proper did not show any increased effect upon corrosion. Structural parts under stress or which were formerly subjected to cold-deformation without having been normalized were attacked more than others. Ha (13)

Mechanism of Oxidation of Mg Alloys and Ca Alloys at Elevated Temperatures (Mécanisme d'Oxydation des Alliages du Magnésium et de Ceux du Calcium à Température Élevée). ROBERT DELAVAULT. *Comptes Rendus*, Vol. 199, Sept. 10, 1934, pages 580-582. Describes appearance of surface of above alloys during oxidation. FHC (13)

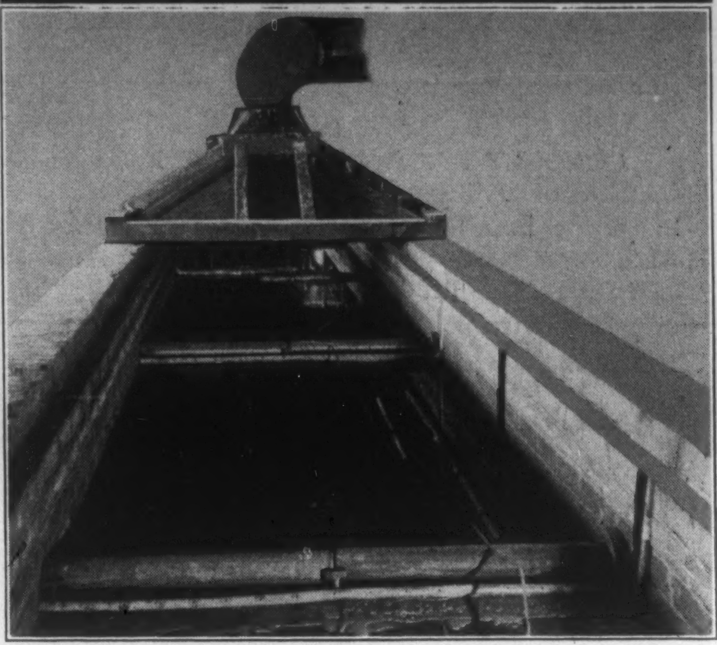
Experience in Germany Proves that Metals can Be Made Heat Resistant by Spraying with Aluminum. C. H. DAESCHLE. *Metallizer*, Vol. 2, July 1934, pages 2-3. As an improvement over the calorization process of making iron or ferrous alloys heat resistant, aluminum may be applied by the metal spray process to any desired thickness and heated with a suitable flux for a few hours in air tight chamber. This process of alumitization is said to be practicable under a temperature of about 1000° C. Factors affecting the diffusion of aluminum and applications are discussed. BWG (13)

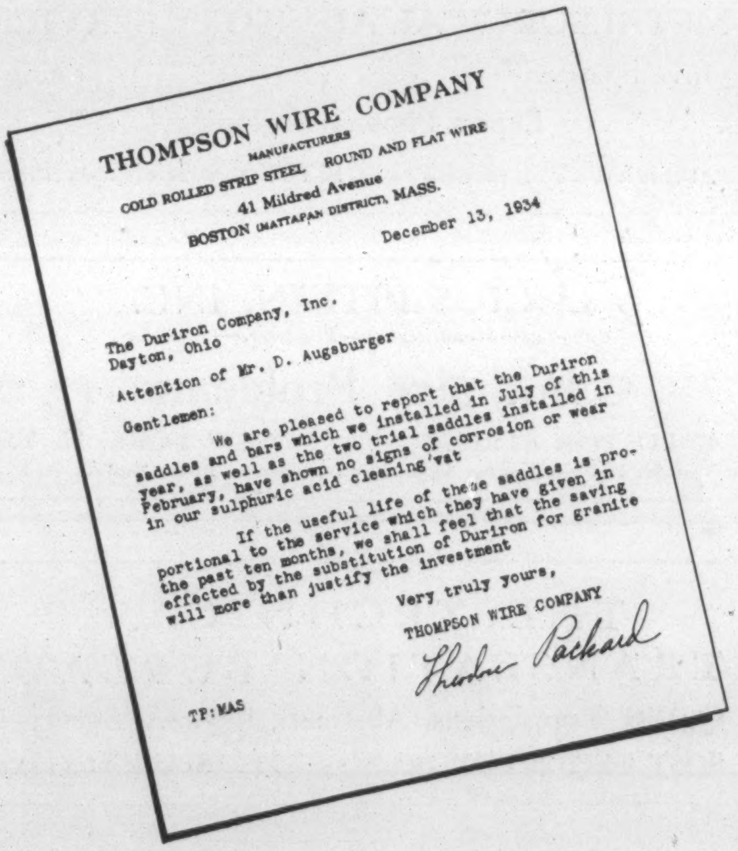
Metallographic Investigations on Destruction by Cavitation (Metallographische Untersuchungen zur Frage der Kavitationszerstörungen). H. SCHROETER. *Zeitschrift Verein deutscher Ingenieure*, Vol. 78, Oct. 6, 1934, pages 1161-1162. Actual tests made in a hydro-power station with a water jet running at 60 m./sec. through nozzles of and against different materials corroborated previous results that the destruction of metals by cavitation is an entirely mechanical phenomenon caused by the collapse of the vapor bubbles in the water which is accompanied by pressures which may easily exceed the strength of the metals. The "implosion" phenomenon must be considered as principal cause for the final destruction although the contact of metal-vapor-water may cause chemical or electrochemical effects which, however, could not be determined. Micrographs illustrate places where implosions took place. Ha (13)

Outdoor Test Results on Bare and Metal-Coated Ferrous Specimens. C. D. HOCKER. Symposium on the Outdoor Weathering of Metals and Metallic Coatings. *American Society for Testing Materials*, Washington Regional Meeting, Mar. 1934, 19 pages; *Iron Age*, Vol. 133, Apr. 5, 1934, pages 34, 78, 80 (abstract). This paper reviews the field corrosion tests of Committee A-5 and includes the following. Black iron and steel sheets: a content of copper up to at least 0.15% substantially improves the corrosion resistance to the atmosphere, but corresponding improvements were not found in tests under water. Hot-dip zinc-coated sheets: the time required for the development of first rust spots as well as subsequent progressive rust development is illustrated for several test locations by curves. Zinc-coated commercial hardware: (1) the coatings are judged to be distinctly less uniform than hot coatings on sheets; (2) hot-dip zinc coatings are showing themselves better than electroplating or sherardizing which appear about equally protective; (3) shapes of specimens distinctly affect the uniformity of plated coats; (4) evidence of selected specimens indicates that all three types of zinc coatings can be equally protective when good uniformity is attained. Other coatings on commercial hardware: (1) hot-dipped aluminum coatings afford good protection; (2) parkerizing shows up poorly in the tests; (3) lead coatings are generally poor, but seem to approach parity with the best coatings in industrial atmospheres; (4) the cadmium plated specimens under test are consistently less protective than the plated zinc ones. VVK + VSP (13)

How Soon Is It Safe to Draw Conclusions? (A Discussion of the Early Interpretation of Test Results in the Atmospheric Corrosion of Non-Ferrous Metals and Alloys). W. H. FINKELDEY. Symposium on the Outdoor Weathering of Metals and Metallic Coatings. *American Society for Testing Materials*, Washington Regional Meeting, Mar. 1934, 19 pages. An analysis of the data collected by Subcommittee VI on Atmospheric Corrosion and Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys from their atmospheric corrosion tests of non-ferrous metals and alloys now in progress in 9 different atmospheres. The following conclusions are drawn. (1) In industrial or large city atmospheres the greatest resistance to corrosion is shown by antimonial Pb, chemical Pb, pure Sn, Cu-rich alloys (such as Al-bronze, Sn-bronze, the Cu-Si-Mn alloy, high-Cu (85% Cu), brass, commercial Cu (both tough pitch and phosphorized), commercial Al, Al coated duralumin, and the Al-Mn alloy. (2) The metals and alloys showing the least resistance to corrosion in industrial atmospheres are Ni, Zn (including high grade, extra high purity and prime western) and the two Al alloys, duralumin and the Al-Mg-Si alloy. (3) The Cu-Ni alloys (Cu-Ni-Zn, Cu-Ni-Sn) and the 70-30 Ni-Cu alloy, as well as Mn-bronze and 70-30 brass, all indicate a resistance to corrosion in industrial atmospheres somewhat lower than commercial Cu. (4) The resistance to corrosion of Ni and the Cu-Ni alloys in marine atmospheres is in sharp contrast to their performance in industrial atmospheres. Ni, the Cu-Ni-Zn alloy, the Cu-Ni-Sn alloy, the 70-30 Ni-Cu alloy as well as antimonial Pb and chemical Pb show the greatest resistance to corrosion in marine atmospheres. (5) The least resistance to corrosion in marine atmospheres is shown by the three types of commercial Zn, Sn, and duralumin. (6) The high-Cu alloys (Cu-Si-Mn, Sn-bronze, Al-bronze) and commercial Cu (tough pitch and phosphorized) show a lower resistance to corrosion in marine atmospheres than the Ni-Cu and Pb alloy group and a still lower resistance to corrosion in this type of atmosphere is indicated by the brasses (both the 85-15 and the 70-30) as well as the Mn-bronze. (7) The corrosion resistance of commercial Al and the Al alloys in marine atmospheres is quite different from their resistance in industrial atmospheres. With the exception of Al-coated duralumin, these materials show a susceptibility to corrosion in marine atmospheres almost as great as that of Zn and unprotected duralumin. (8) In general most of the non-ferrous metals and alloys included in these tests appear to be more corroded by the industrial type of atmosphere than by a marine type atmosphere. Corrosion in the rural atmospheres is on the whole too slight to permit drawing any conclusions regarding the data. (9) With particular respect to the estimation of corrosion resulting from short-time exposures, it is apparent that not any one method used by Subcommittee VI of Committee B-3, to measure corrosion is entirely satisfactory. The best combination of methods appears to be a determination of the loss in weight using cleaned specimens, coupled with tension tests to indicate any irregular, pitted or intercrystalline type of attack which might occur. There is, however, a general agreement between the ratings of relative corrodibility as determined by the three methods used to measure corrosion (change in weight, loss in tensile strength and loss in elongation). (10) Visual examination of weathered surfaces is of little use as a direct measure of corrosion once the latter gets beyond the tarnish film stage. VVK (13)

DURIRON for Corrosion and Abrasion





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December 13, 1934

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Dayton, Ohio

Attention of Mr. D. Augsburger

Gentlemen:

We are pleased to report that the Duriron saddles and bars which we installed in July of this year, as well as the two trial saddles installed in February, have shown no signs of corrosion or wear in our sulphuric acid cleaning vat

If the useful life of these saddles is proportional to the service which they have given in the past ten months, we shall feel that the saving effected by the substitution of Duriron for granite will more than justify the investment

Very truly yours,

THOMPSON WIRE COMPANY

Theodore Packard

TP:MAS

The Duriron saddles and bars replaced granite bars. Directly below the fume hood are two granite bars badly worn after only two years of service.

Even at the low cost of granite, Mr. Packard feels that Duriron will justify the investment, judging from the service given in the past ten months.

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●

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APPLICATIONS OF METALS & ALLOYS (14)

Material, Methods and Elements of Modern Engineering (Matériaux, Méthodes et Elements de la Construction Mécanique Moderne). *La Technique Moderne,* Vol. 26, June 15, 1934, pages 398-401. Reviews developments in (1) structural steels, (2) alloy steels, (3) Cu alloys: Ni-Mn brasses, (4) Al alloys, (5) assembling devices, (6) motion transmitting devices, (7) lubrication. FR (14)

Steel-Aluminum Cables for High Tension Lines (Stahlaluminiumseile für Hochstspannungsleitungen). FRANZ BUSKE. *Elektrizitätswirtschaft,* Vol. 33, May 15, 1934, pages 164-166. Contrary to the German standards, the utilization of steel-Al cables with a reduced Al and enlarged steel cross section are advocated for 100,000 volts. Reduced cable costs, smaller amount of sagging, larger suspension lengths and reduced heights of the masts for overhead transmission lines are claimed as advantages. Suggestions on a 220,000 volt line of Al-steel are furnished and comparison is made with an equivalent 25 mm. hollow Cu cable. Magnetization losses of steel-Al cables are insignificant and can be practically neglected. WH (14)

Metallurgical Advances Reflected in Engineering Design. ROBERT W. CARSON. *Metals & Alloys,* Vol. 5, Oct. 1934, pages 217-220. Engineering design has taken advantage of metallurgical advances particularly in the development of high speed railway equipment, modern automobiles, airplanes and in skyscrapers. Light strong alloys of Al and Mg, stainless steels, improved corrosion and heat resisting alloys, better bearing metals and higher strength alloys have been chief contributors to this advance. WLC (14)

Saving Money by Using Costly Metals. R. WOSAK. *Product Engineering,* Vol. 5, Oct. 1934, pages 362-365. A comparison of a Diesel engine made of C steel and cast Fe with one built of modern light metals and alloy steels shows saving in weight and fuel consumption obtainable. Ha (14)

Steam and Power Supply. VERN E. ALDEN. Paper presented at annual meeting of American Society of Mechanical Engineers. *Mechanical Engineering,* Vol. 55, Nov. 1933, pages 667-672; Discussion: *Mechanical Engineering,* Vol. 56, Aug. 1934, pages 480-483. Metallurgical problems and considerations are involved in planning steam and power projects for industrial plants; for example in choice of initial steam pressure and temperature which must take account of quality of water, extent to which multi-stage heating of feedwater and air is to be used, etc., also various fuel questions. Discussers deal largely with costs. MFB (14)

Modern Welds and Metals for a Heater. F. C. WOODSIDE. *Metal Progress,* Vol. 26, Sept. 1934, pages 30-33. Describes modern domestic heating plant with welding and metal selections whose control assures good unit. WLC (14)

Non-Ferrous (14a)

G. L. CRAIG, SECTION EDITOR

Investigation to discover a Substitute for Platinum as Anode in Electrolytic Oxidation Processes. Part II. Tests with Lead Peroxide Anodes. (Untersuchungen um einen Ersatz für das Platin als Anodenmaterial bei elektrolytischen Oxydationsverfahren zu finden). GÖSTA ANGEL & HJALMAR MELLQUIST. *Zeitschrift für Elektrochemie,* Vol. 40, Oct. 1934, pages 702-707. A film of lead peroxide was produced on Fe, Cu and Au plated Fe and Cu from alkaline lead tartrate solution. Chlorate solutions electrolyzed with and without chromate and borate additions with current density 20 amps per dm^2 and efficiency of 79.2% at 15°C showed no injury to lead peroxide film in production of perchlorate. WB (14a)

Ten Bus Men Discuss the Pros and Cons of Pistons. Cast Iron vs. Aluminum. *Bus Transportation,* Vol. 13, June 15, 1934, pages 203-204. Answers to a query on the merit and shortcomings of cast Fe, Al and cast Fe-Sn plated pistons. The opinions based on practical experiences are divided. Half the answers favor Al pistons because of wear resistance, less vibration, better cooling due to rapid heat dissipation, less tendency to detonate, less C formation due to lower piston temperatures, faster acceleration, better suitability for new higher compression and high speed service. Shortcomings found with Al are tendency to wear cylinder walls more rapidly and greater oil consumption. Advantages claimed for cast Fe are 10-120% longer life (except in high speed buses) and less wear where dirt passes through the carburetor into the engine. WH (14a)

Studies on Magnesium Light (Studien über das Magnesiumlicht). J. A. M. VAN LIEMPT & J. A. DE VRIEND. *Recueil des Travaux Chimiques des Pays-Bas,* Vol. 53, July 15, 1934, pages 839-846. Quantitative optical measurements on Mg wire and strip. Light yield during combustion of Mg in O_2 = 28 lm./W. Combustion in NO and N_2O is slower than in O_2 and none takes place in SO_2, CO, CO_2 and NO_2. Spectrum of Mg light proves its superiority to daylight for photographic purposes. A new light unit (lm. sec.) based on a defined quantity of Mg is introduced. Measurements showed that 1 lm. sec. = 1.43 x 10^{-6}g.Mg. (± 1%). EF (14a)

Studies on Zirconium Light (Untersuchungen über das Zirkoniumlicht). J. A. M. VAN LIEMPT & J. A. DE VRIEND. *Recueil des Travaux Chimiques des Pays-Bas,* Vol. 53, July 15, 1934, pages 895-898. Quantitative tests on Zr as flashlight material. Zr burns slower in O_2 than Mg, yields an almost continuous spectrum superior to daylight. EF (14a)

Aluminum in Overhead Transmission Lines. (Aluminium im Freileitungsbau). W. ZIMMERMANN. *Elektrizitätswirtschaft,* Vol. 33, May 31, 1934, pages 196-137. Data on the utilization of Aldrey (98.7 Al, .3 Fe, 1 Si + Mg) for high-tension cables in Europe are given. Two diagrams show the tensile strength of Cu, Al and Aldrey wires during long time exposures to 75°-80°C. and dependence of tensile strength of these materials on temperature (20°-100°C.) during continuous heating for 180 days. The loss of strength of Aldrey is much less than that of Cu. Aldrey is slightly less conductant than pure Al, shows the same strength as a steel/Al cable of the same electric properties, but weighs 35% less. Corona losses are lower due to the larger cross section of Aldrey as compared with Cu cables of equivalent electrical properties. Endurance failures experienced with Al are not reported with Aldrey in Switzerland. Failures in Germany are attributable to faulty suspension devices of the earlier days. Arrives at the conclusion that Germany intentionally neglected the utilization of Al for overhead transmission lines in comparison with Cu due to lower corrosion resistance, inferior physical properties, smaller suspension lengths and former actual failures. The author states that these shortcomings are greatly minimized. WH (14a)

Copper Cylinder Heads. H. W. RISTEEN. *Automotive Industries,* Vol. 71, Nov. 10, 1934, page 593. This Forum letter describes results of a preliminary investigation of the use of cast Cu cylinder heads for internal combustion engines (as an improvement over cast Fe or cast Al), recently conducted at the Michigan College of Mining and Technology. Using a series of heads varying in compression ratio from 6:1 to 8.5:1 the spark advance for incipient knock was determined for each of the materials, using a single cylinder gasoline engine. The Cu head because of its high heat conductivity was found to permit about the same compression increase over Al as Al permits over cast Fe, such as a ratio of 8.2 for Cu, 7.6 for Al, and 7.1 for Fe for a given spark advance. Additional work on the effect of various designs has been started. BWG (14a)

Applications of Metallizing in Ship Building Field are Increasing Rapidly. S. R. MORRISON. *Metallizer,* Vol. 2, Aug. 1934, pages 5-6. A discussion is given of the advantages of metal spraying various parts of ship and their equipment; also, the procedure in rebuilding worn shafting and pitted propellers. Zinc was largely used for coating such parts as deck plates, shell plates, ventilator cowls, cargo hatch battens, etc., and lead was sprayed on iron boss plates, the stern frame, and shell plates to be installed below the water line. BWG (14a)

New Wire Permits Babbitt-Sprayed Bearings. A. H. LEVY. *Metallizer,* Vol. 2, Aug. 1934, pages 9-10, 14. Difficulties in making a babbitt wire of sufficient strength to be drawn to the proper size and used in the spray gun have been overcome. The bond is said to be much better than with cast babbitt linings as the babbitt is blown against a sand blasted backing with such force that the particles imbed themselves securely into the depressions of the rough surface. Tinning is not required and anchoring is not essential. There is no danger from blow holes and linings of extreme thinness may be produced. Bronze bearings may be improved by spray coating with babbitt. Rebuilding old worn babbitt linings is not recommended. BWG (14a)

Reference Tables for Platinum to Platinum-Rhodium Thermo-Couples (Tabellen für Platin-Platinrhodium Thermoelementen). WM. F. ROESER & H. T. WENSEL. *Zeitschrift für Instrumentenkunde,* Vol. 54, May 1934, page 170. See *Metals & Alloys,* Vol. 5, Nov. 1934, page MA 542. EF (14a)

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Application of Zinc Alloys to Gas and Water Distribution Devices and Piping in Dwellings (Les applications des alliages de zinc au conduits et appareils de distribution d'eau et de gaz dans l'habitation). R. Cazaud & H. Petot. *Génie Civil,* Vol. 105, July 1934, pages 34-37. Zn-Al alloys containing 6 Sb, Mg Ti patented under the name Totalin (*total*ement *in*oxidable) are described. Their microstructure is adjusted to produce the tightest and most adhering protective film in the shortest time. Alloys contain 5 to 25% Al, and are composed of a mixture of the eutectic with a solid solution. Sand cast 10 and 15% Al binary alloys have tensile strength 25 kg./mm.^{2} and elongation 8.5 and 3% respectively. Chill cast 14, 17 and 20% Al alloys have elongation of 2% and tensile strength of 21, 24, 21.2 kg./mm.^{2} respectively. In hot rolled state 20% Al alloy has tensile strength of 25.9 kg./mm.^{2} and elongation 20%. Small quantities of other metals added to Zn-Al alloys containing more than 5% Al markedly change their physical and microscopic properties. Perfectly homogeneous structure is obtained in 14% Al alloy by adding 0.5% Sb giving 28 kg./mm.^{2} tensile strength and 85 hardness. With 20% Al and 0.5% Sb 33 kg./mm.^{2} 7 is obtained for tensile strength and 120 for hardness (all in chill cast state). Alloys up to 20% Al can be rolled, forged and drawn. Mg additions are good, Cd, Bi and Sn the least promising. Bright and strong pipes were manufactured under a press from these alloys with the properties:

Pipe diameter mm.	Composition % Al	Elastic limit kg./mm.^{2}	Tensile strength kg./mm.^{2}	Elongation %
33-38	5	26	30.5	23
10-15	10	19	32	25
26-30	10	26.5	31.8	35

8 These pipes bend without cracking around a mandrel with the diameter equal to 10 fold diameter of the pipe and in a heated state around a mandrel with the same diameter as the tube. At 300°C they can be formed in any shape. Pipes withstand hydraulic testing well and are inexpensive. JDG (14a)

Investigation to Discover a Substitute for Platinum as Anode in Electrolytic Reduction Processes. Part I. Tests with Tungsten Anodes (Untersuchungen um einen Ersatz für das Platin als Anodenmaterial bei elektrolytischen Oxydationsverfahren zu finden). Gösta Angel. *Zeitschrift für Elektrochemie,* Vol. 40, Sept. 1934, pages 641-647. 9 Platinum anodes used in the production of perchlorate, persulphate, perborate and other anodic oxidation products. Cost of Pt is incentive for search for substitutes. Graphite unsuitable because of disintegration, magnetite gives high potential and low efficiency. The literature states that W, Mo, Nb, V and Ta form oxide films and are resistant to attack by acids and oxidizing solution. Commercial use of V for perchlorate showed the V salts catalyzed the decomposition of the perchlorate and Nb and Ta form oxide films with high electric resistance. Tests with W anodes with and without Pt conducting wires showed corrosion to be considerable. Mo anode behaved similarly. W and Mo anodes considered unsuitable as Pt substitutes. WB (14a)

Light Metal Pulleys for Cables (Roues à gorge en métal léger pour Téléphérique). 10 A. M. Hug. *Revue de l'Aluminium,* No. 61, May 1934, pages 2415-2417. Duralite is very appropriate for such pulleys according to tests made in Italy. Duralite contains 3% Cu besides Fe, Si, Mg, Ni and Ti. Heat treated sand castings of this alloy have the following properties, elastic limit 22-27 kg./mm.^{2}, tensile strength 25-32 kg./mm.^{2} elongation 6%, Brinell 100-130. AH (14a)

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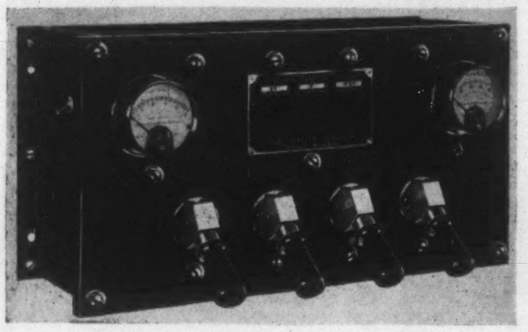
NEW EQUIPMENT & MATERIALS

New Plating Rheostat

For all electroplating processes, The Udylite Company, Detroit, Michigan, has designed and built a rheostat into which are incorporated the features of close current regulation, ruggedness, compact construction and simplicity of operation. The efficiency of any rheostat depends largely on the performance of its switches. Therefore Udylite engineers have chosen self cleaning, constant pressure, cam type switches of their own improved and refined design. These refinements, together with improved methods of manufacturing result in a rheostat switch which is definitely superior to any on the market. The cam switch used is designed to provide perfect contact at the low plating voltages. This perfect contact is ensured by grinding the switch leaves when the switch is in a closed position. Ample contact surface and current carrying capacity have been provided. The contact pressure firmly holds each leaf perfectly flush against the bus bar wihout distortion. Pressure is always perpendicular to the contact surface. It is equalized on all leaves and is equally divided between the 2 contact surfaces. Inner and outer leaves are made of heavy spring bronze while the current carrying center leaves are of spring brush copper. These materials maintain their shape indefinitely. The leaves of the Udylite cam switch are actually multiple cleaning units. They provide a wiping action on the surface of the bus which keeps the contact surface clean and ensures positive contact at all times and at all points. The switch, when open, cannot make an accidental sparking contact because of the sturdy steel spring which holds it away from the bus bar. The resistors are of helical coiled, nichrome wire. The low amperage coils, which generally receive hardest service, are over-dimensioned for higher voltage drops. Coil brackets have unusually large radiating surface resulting in cooler contacts of the resistor coils. Cooling of the resistors is accomplished by a chimney draft action. Cool air is drawn upward through the resistors enclosed on four sides by the rheostat casing. These improvements in rheostat construction eliminate overheating.



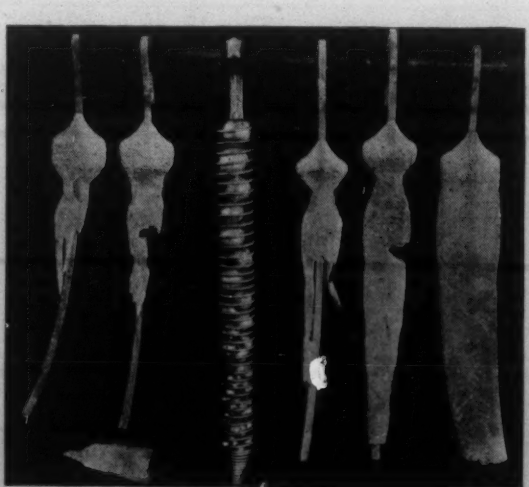
New Portable Potentiometer

The Brown Instrument Company, Philadelphia, Pa., announces a new portable potentiometer designed to enable pyrometer users to check their potentiometers, millivoltmeters and thermocouples quickly and accurately. The combination of a step-switch and slide wire makes it possible to read the indicating scale to .01 millivolts over a total range of 71 millivolts. This step-switch and slide wire combination is equivalent to having a slide wire 109" long. The indicating scale is 17" long, making the smallest scale division (.05mv) over 1/16" in width. A fully enclosed, suspension type galvanometer is used. Having a very short period (approximately 2 seconds) readings can be taken rapidly, as the galvanometer responds immediately when dial is moved to a new position. Two sets of binding posts and a toggle switch, provided for thermocouple checking, further facilitate taking check readings quickly and accurately. The potentiometer circuit has been designed primarily for checking pyrometers and thermocouples. In addition, this new portable potentiometer can be used as a measured source of e.m.f. in checking recording potentiometers of the self-balancing type. The circuit draws only 3 milliamperes from the dry cell, giving the dry cell a life of several months and permitting the instrument to be used for several hours on one standardization of the battery current. In addition to being simple in construction and extremely accurate, this new Brown Portable Potentiometer is small in size and light in weight. It is 9⅜" wide x 10¼" deep x 6¾" high, and weighs only 12¾ lbs.

THE BROWN INSTRUMENT COMPANY
PHILADELPHIA, PA.
THE BROWN INSTRUMENT COMPANY
PHILADELPHIA, PA.

Ball Anode Patented

U. S. Patent Reissue 19328 covering ball anodes for electroplating and containers for same has recently been granted by the United States Patent office. Through this new patent, The Udylite Company, Detroit, Michigan, now has exclusive rights to manufacture, sell and use ball and spheroidal anodes for electroplating. The features of the ball anode are several. One of the most important is the maintenance of constant anode area at all times. This makes it possible to keep the metal content of the plating bath constant without the necessity of expensive salt additions. Another important feature is the elimination of scrap metal losses. As the ball anodes corrode, they diminish in diameter and descend in the container. Fresh balls are added at the top. Even the smallest scraps of anode material are completely used up. The ball anode provides, in addition, a convenient method of anoding. The containers are filled from the top and in even the largest installations, this operation involves but a few minutes of one man's time.



Dowmetal "H" Sand Casting Alloy

The Dow Chemical Company, Midland, Mich., announce that Dowmetal "H" is now included with the other Dowmetal sand casting alloys because of its high mechanical properties and improved corrosion resistance. A combination of properties hitherto not obtained on Magnesium alloys is accomplished by the application of Heat Treatments No. 1a and No. 3a.

Chemical Composition

Al	Mn	Zn	Mg
5.5-6.5%	0.18% Min	2.7-3.3%	Remainder

Physical Properties

Specific Gravity (75°F.)	1.84
Weight lbs./in.³	0.066
Melting Point °F.	1155
Coefficient of Thermal Expansion per °F. (65°-750°F.)	0.000016

Sand Castings

Dowmetal "H" may be used for sand castings with the same general technique that is applied to other Dowmetal casting alloys. The same patterns may be used as the shrinkage factor is unchanged. The heat treatment of Dowmetal "H" involves a slight change in the procedure as applied to other Dowmetal alloys. H.T. No. 1a is a solution heat treatment, and H.T. No. 3a is a solution heat treatment followed by complete aging or precipitation.

Mechanical Properties

The mechanical properties obtained on sand cast test bars in the as cast and heat treated conditions are given in the following table.

Condition	Tensile Strength lbs./in.²	Yield Strength lbs./in.³	Elongation %
As Cast	25-30,000	11-13,000	4-8
H.T. No. 1a	33-38,000	11-14,000	9-13
H.T. No. 3a	37-42,000	18-21,000	3-7

Corrosion Resistance and Surface Finishing

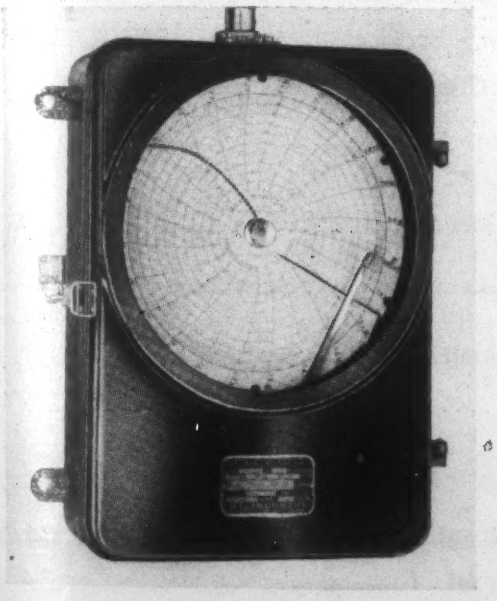
Dowmetal "H" has approximately 3 times the corrosion resistance of Dowmetals "F," "A," and "G" when subjected to alternate immersion in 3% salt solution. Castings made from Dowmetal "H" respond to the Chrome-Pickle treatment and may be painted subsequently the same as other Dowmetal alloys.

New Type Expansion Joint

An ingenious method of caring for expansion in a long pipe line has been provided in the huge air duct, recently completed for the Milwaukee Sewage Disposal Plant at Jones Island, with flanged connections which permit enough flexibility to prevent distortion of the pipe under longitudinal stresses. This large installation, comprising a tube of Plykrome, a stainless clad steel, ranging from 2 to 5 ft. in diameter, was assembled at the Island in 54-ft. lengths where it was welded into a continuous tube 1800 ft. long. Inasmuch as the tube carried 100,000 cu. ft. of air per minute under a pressure of 10 lb. per sq. in., perfectly welded joints were imperative to prevent leakage. The Cream City Boiler Company, who completed the work for the city of Milwaukee, used P&H Hansen welders in the fabrication and installation of the pipe. This new type of expansion joint, made under patents held by the Allis-Chalmers Mfg. Company, occurs at intervals of 54 ft. The flange, or collar, protrudes from the outer edge of the pipe from 4½ to 6-5/16 in. depending upon the variable diameter of the tube. The pipe connections themselves are separated by 1 in. of air space, amply allowing for expansion and contraction under the most severe temperature changes.

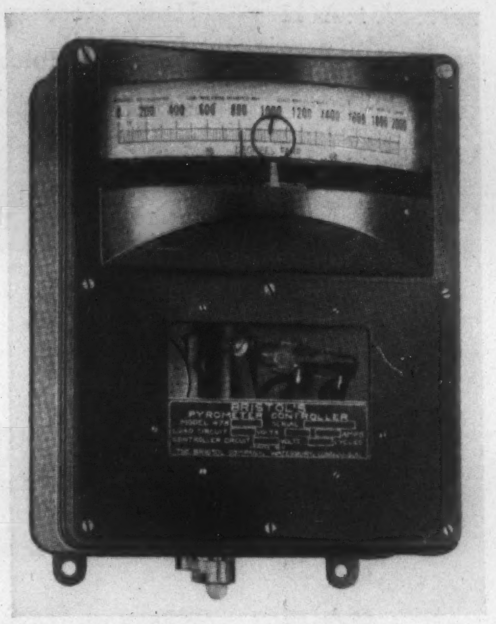
A New Recording Pressure Gage

A new direct reading absolute pressure gauge of the recording type has been developed by The Bristol Company, Waterbury, Conn. It is a recording vacuum gauge which is compensated for changes in barometric pressure and is also compensated for changes in temperature. It, therefore, reads direct in pressure absolute. Scientists have long been interested in the development of measuring instruments for pressure which could be so compensated as to read direct in absolute pressure without the need for applying various complicated corrections. In industry, however, a greater need has developed in many processes for direct reading recording type of absolute pressure gauge which could be used by miscellaneous operators and practical men and read direct without confusing their minds or being delayed by any necessity for applying barometric or temperature corrections. The use of high vacuum is now an important feature in production processes such as vacuum processes in oil refineries and many other miscellaneous processes in chemical plants. The Bristol recording absolute pressure gauge is equipped with two measuring elements which are coordinated through a special differential transmitting linkage of ingenious design. One measuring element is connected to the vacuum line and the other functions in connection with the compensating features of the recorder. This instrument can be furnished for ranges as low as 25 mm. head of mercury absolute pressure or its equivalent. The recorder is available in rectangular form case of wall type or flush type design.



A New Pyrometer Controller

The Bristol Company, Waterbury, Conn., announces a new pyrometer controller, Model 478, which is claimed to possess "degree-splitting" characteristics that permit an unflinching check over any heating process, and precision "shear-edge" action of the working mechanism which raises product quality to new standards of uniformity. The new model has several outstanding features: (a) clean, non-arcing, nonoxidizing, non-corroding mercury-to-mercury electric contacts, sealed in glass; (b) no need for relays; (c) operating mechanism always visible; (d) accessibility of telechron motor, mercury switches and terminal block, simplifying field inspection without exposing control mechanism to dirt, fumes, or misalignment; (d) full safety features; (e) accurate control; (f) simple and rugged working parts.



A New Portable Pyrometer

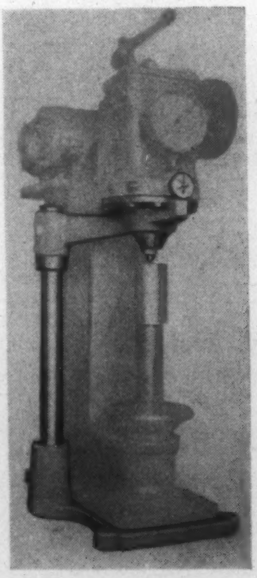
The Russell Electric Company, 339 West Huron Street, Chicago, Ill., is now offering a pyrometer of the portable lance type for $16.00. This price includes the complete equipment with the exception of the thermocouples which vary in price depending upon the type. Meters are available for three different temperature ranges of 800°-1600°-2500° F. The instruments are of the low resistance type and are pointed to as combining high accuracy with rugged construction. In design they are of the streamlined type to conform with modern tendencies. The entire protecting case and handle is a single aluminum casting. These portable hand instruments may be used for checking temperatures in all the applications where a wall type pyrometer is used. For general use they have the additional advantage of portability. The company claims that the equipment is ideal for checking each melt of non-ferrous metals to insure that it is poured at the proper temperature and also that it is valuable for checking oven and furnace temperatures, salt and oil baths, heat-treating machines and other equipment. Besides special types of thermocouples for different applications, there is included a silver disc contactor for quickly exploring surface temperatures.

Improved Rubber Tank Lining

The research division of the American Hard Rubber Company of New York has just announced a definite improvement in rubber linings for tanks used in processing operations employing highly corrosive solutions. The new lining, known as M R-10, is characterized by a high glaze surface which offers greater resistance to acids and alkalis and is more easily cleaned. The outer layer of glazed rubber is securely bonded to a relatively thin inner layer of soft rubber which is in turn vulcanized to the steel tank. This soft rubber lamination provides an elastic contact which compensates for contraction and expansion of metal and rubber during changes of temperature. It also acts as a shock absorber to protect the lining against accident and abuse. Another feature of the new lining is the use of heavy soft rubber fillets underneath the lining in all corners. The new lining is made of a better rubber compound which is said to offer longer and more efficient service as proved by actual service and laboratory tests. Sample test pieces are offered free to any manufacturer interested. The new lining is being offered at no advance in price.

Direct Reading Brinell Attachment

Of particular interest to those doing extensive Brinell testing is an attachment recently introduced by the Detroit Testing Machine Company, Detroit, Mich., the use of which is said to reduce testing costs by more than half. This device in conjunction with a Brinell machine enables the operator to check the hardness of parts or specimens without the use of a microscope. In most cases grinding or spotting is unnecessary and equally good results are obtained on flat, rounded or odd surfaces. Tolerance hands are set to the desired limits and the operator merely notes whether or not the pointer stops between them. In addition to the economies effected the usual congestion around the machine is greatly reduced.



The construction is unique in that the indicating instrument is supported independently and errors due to frame deflection or distortion are said to be entirely eliminated. A degree of accuracy hitherto unattainable is claimed for it. This arrangement also makes the device adaptable to all makes of existing machines including those with a deep work gap or of special design. Although developed primarily for use on power driven Brinell machines, it may be used to advantage on the hand-operated type where large numbers of similar pieces are to be tested. The actual test made is the standard Brinell test which may be checked at any time with the microscope. A rate of 600 tests per hour is claimed possible under favorable conditions.

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